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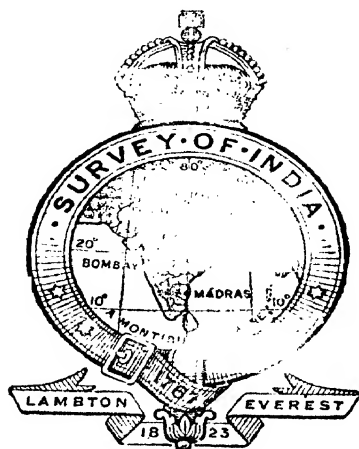
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SURVEY OF INDIA

GENERAL REPORT

1928 TO 1929



**From 1st October 1928
To 30th September 1929**

**PUBLISHED BY ORDER OF
BRIGADIER R. H. THOMAS, D.S.O.
SURVEYOR GENERAL OF INDIA.**

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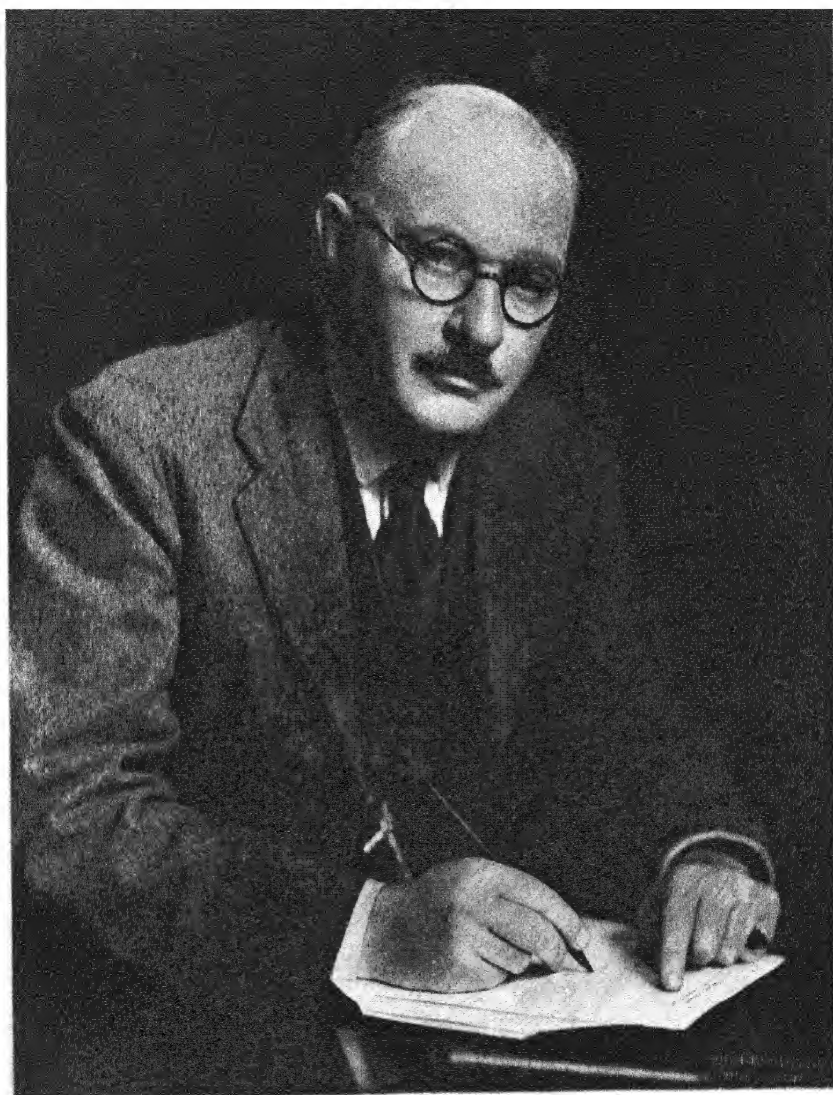
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BRIGADIER SIR EDWARD ALDBOROUGH TANDY, R.E.,
SURVEYOR GENERAL 1934-38.

SURVEY OF INDIA

GENERAL REPORT

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1929.**

PREFACE.

THE WORK OF THE SURVEY OF INDIA.

The department is primarily responsible for all topographical surveys and explorations, and for the maintenance of geographical maps of the greater part of Southern Asia. Also for geodetic work, which includes:—the main trigonometrical framework, extending in some cases far beyond the frontiers of India, and control networks of precise levelling based on tidal observatories; tidal predictions and the publication of tide tables for nearly 40 ports between Suez and Singapore; the magnetic survey; astronomical, seismographic, and meteorological observatories at Dehra Dūn; and geodetic investigations of an international character, in regard to which India enjoys a unique position between the greatest highlands of the world and a deep ocean extending to the Antarctic. Indian geodesy has thus disclosed by far the largest known anomalies of gravitational attraction in the earth's crust, and these have led to some of the most important developments of modern geodetic research, whilst the Great Trigonometrical Survey of India enjoys an international reputation as a very valuable contribution to estimates of the size and figure of the earth. The calculations of astronomy and some important data in physics depend ultimately on these terrestrial measurements.

In the past the department has also carried out the original large scale revenue surveys for most of India, and was still conducting this work for Central and Eastern India and Burma up to 1905, when all revenue surveys were handed over to the Provinces concerned, together with officers and staff as required, in order to concentrate the energies of the department on a complete new series of modern topographical maps on the 1-inch = 1 mile scale. It was hoped to complete this series by 1930, but owing to retrenchment and the war little more than half has been done up to date, in spite of the reduction of the scale of survey for less important areas. Thus, although new surveys covering an area about equal to that of England are carried out every year, the maps of half the country are still very old and only kept up to date roughly by means of rather perfunctory information supplied by local officials; the old maps are also about two miles out as regards geographical position, being based on a longitude of Madras determined in 1815.

Boundary surveys and records of international, state, and provincial frontiers have always formed an important item of topographical work; and in recent years there has been considerable progress in the preparation of Guide Maps for important cities and military stations, where the 1-inch = 1 mile scale is quite inadequate.

Miscellaneous. While expending on topographical and geodetic work all funds allotted by Imperial Revenues, the department is steadily developing the policy of aiding local surveys in various ways, on payment by those concerned. These miscellaneous operations include: all forest and cantonment surveys: many riverain, irrigation, railway, and city surveys, and surveys of tea gardens, mining areas, &c., with a great deal of control levelling for the same: administrative assistance and officers are also given in aid of the revenue surveys of various Provinces and States. The Printing Offices do much work for other Government departments, such as printing special maps, illustrations for Archeological Reports, all diagrams for Patents, &c. The Mathematical Instrument Office gives valuable aid to all Government departments by maintaining a high standard of instrumental equipment, especially in connection with optical work, and by the manufacture and repair of high-class instruments which would otherwise have to be imported from abroad.

Military, &c. The department is also responsible for all survey operations required by the Army, and has been rapidly developing measures to meet the greatly increased complexity of modern military requirements, especially in connection with air survey. In view of its high military importance, air survey work for various civil purposes is receiving all possible encouragement and assistance, while the latest methods of stereo-photography are being studied experimentally.

Administration is by the Surveyor General under the Education, Health and Lands Department of the Government of India. The Headquarters Office is at Calcutta under the Assistant Surveyor General, and there are seven Directors, one for each of the five Survey Circles into which the country is divided, one for the Geodetic Branch at Dehra Dūn, and one for the Map Publication and other technical offices at Calcutta.

3. *The total cost* of the Department for the past financial year ending 31st March 1929, as compared with that of previous years, was as follows:—

	1926-27	1927-28	1928-29	REMARKS.
	<i>Rs.</i>	<i>Rs.</i>	<i>Rs.</i>	
Gross actual cost ...	59,64,926(a)	58,29,680(b)	58,82,740*	(a) Including Rs. 3,03,336 for English Charges (High Commissioner) on Stores, and loss or gain by exchange.
Deduct receipts and credits	28,28,180	28,24,786	25,50,911*	(b) Including Rs. 3,53,100 for do. do.
Net actual charges ...	86,86,746	85,04,894	33,31,829*	

* These figures are not final.

The total area of new surveys of all kinds completed during the year was 47,888 square miles (p. 25).

4. *Organization.* The whole area of India and Burma is divided for the purposes of the Survey of India into five Circles. The limits of these are shown by blue lines on the index map at the end of the book. In order that civil administrations and the public may know which Director to address on survey matters, a list of Provinces and States comprised in each Circle is given in the loose slip containing Survey Notices.

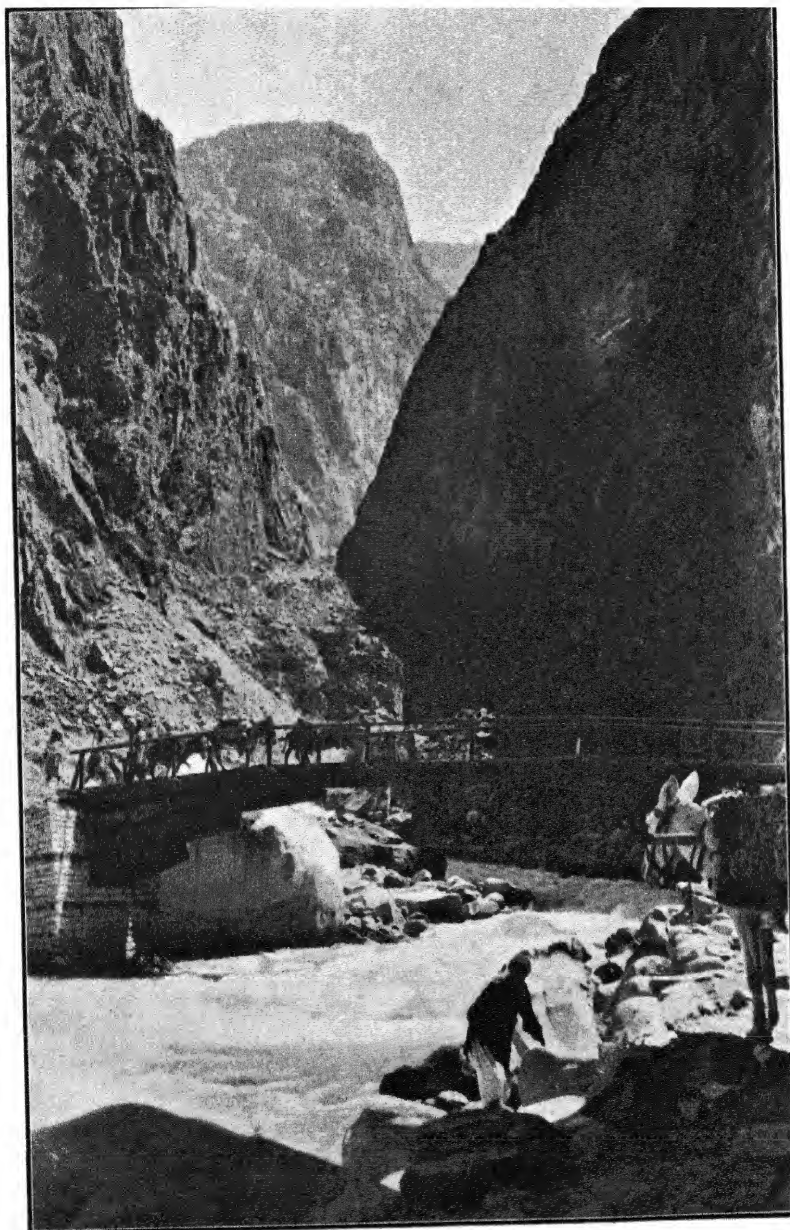
The Engraving Office has been amalgamated with No. 1 Drawing Office as its Engraving Section, with effect from the 1st April 1928; the Copper Plate Printing Section of the Engraving Office being transferred to the Photo.-Litho. Office from the same date. Arrangements are being made for the recruitment of two technical officers from England with a view to introducing brush drawing and effecting improvements in the work of the newly formed section.

Under the orders of the Government of India Nos. 16 and 20 Parties have been designated "No. 16 Party (Publication and Stores)" and "No. 20 Forest and Cantonment Office" respectively, and redistribution of duties has been made accordingly.

In order that the present Mathematical Adviser Dr. J. deGraaff Hunter, M.A., Sc.D., F. Inst. P. may continue to devote his attention to mathematical problems, while holding the post of Director, Geodetic Branch, a senior Class I officer will hold charge of No. 2 Drawing Office and will, as Deputy Director, Geodetic Branch, perform a part of his duties, mostly of a topographical nature.

A temporary executive charge of Officer in charge, Map Publication Office, in place of the post of Chief Draftsman, during the tenure of the post by Mr. E. B. West, has been created.

A detachment entitled the Air Survey Traverse Detachment has been formed under the direct control of the Director, Central Circle, to execute traversing for the control of air surveys in the districts of Sitāpur Bahraich and Fyzābād (p. 53).



BRIDGE OVER THE GOLEN GOL, CHITRAL.

INTRODUCTION AND SUMMARY

The Rājputāna Detachment, which was renamed the Benares Detachment, has been disbanded from 30th September 1929.

The Settlement Survey Detachment was disbanded on completion of its work.

5. Notable events of the survey year were as follows:—

Chitrāl Survey.—The survey of Chitrāl on the 1-inch and $\frac{1}{2}$ -inch = 1 mile scales was completed during the year. The survey required careful organization and considerable enterprise; officers and surveyors with no previous experience of high climbing have triangulated and surveyed in mountainous and glaciated areas involving regular climbing to well over 18,000 feet.

Bhutān Survey.—With the permission of the Bhutānese Durbar, surveyors of No. 12 Party surveyed 790 square miles of previously unexplored country in Bhutān adjoining the British territories (p. 67).

Riverain Surveys.—No. 22 Party has now completed its programme of riverain surveys, and will be diverted next season to special and rectangulation surveys for the Bhakra Dam Irrigation Project, for which the Government of the Punjab have allotted funds. The surveys are to cover an area of about 15,000 square miles and will probably take 5 years to complete.

Mālda Air Survey.—Owing to certain technical difficulties in respect of the Settlement maps produced by the Air Survey Company, the original contract made with the Government of Bengal was not completed. The method of rectification has subsequently been changed to surmount the difficulties experienced; and the maps now being produced have proved quite accurate and satisfactory when tested in the field.

Almorā Experimental Photographic Survey.—Lieut. I. H. R. Wilson, R.E., carried out a small experimental photographic survey in the Almorā district with the Wild Photo. Theodolite. Owing to the width of the valleys it was proved that the Autograph would not plot the country so far from the base stations on the large scale required, viz. 66-inches = 1 mile (p. 42).

Manœuvres.—Major W. J. Norman, M.C., R.E., and Lieut. D. McK. Burn, R.E., with a small map reproduction section attended Northern Command manœuvres in October and November 1928.

'E' Survey Company carried out combined training with the Royal Air Force and Royal Artillery at Quetta during the recess months (p. 45).

A Royal Artillery Survey Section under Captain Culvervell, R.A., spent 8 days at Rāwalpindi during November 1928 and carried out a survey exercise in co-operation with 'A' Survey Company.

Exploration.—His Royal Highness the Duke of Spoleto led an expedition to the Karakoram. A party crossed the Muz-tāgh pass to the Sarpo Laggo glacier and followed up the Shaksgam valley to the Kyagar glacier, discovered by the Survey of India in 1926. A stereographic survey was made of the Bāltoro glacier and various meteorological, magnetic and pendulum observations were carried out, both on the glacier and in Bāltistān. The Duke visited Dehra Dūn in March 1929 and compared his pendulum and magnetic instruments with those of No. 14 Party and the magnetic observatory.

Dr. Filchner has furnished the results of his astronomical observations made during his last Tibetan expedition.

Khan Sahib Afraz Gul Khan was deputed to accompany Mr. P. C. Visser on an expedition to the Karakoram during the summer of 1929. The party has successfully explored the great tributaries of the lower Siachen Glacier. Two long glaciers flow north-west from the head of the Chong-Kumdan and Mamostong glaciers, the first of these being approximately 20 miles long. Almost the whole of the unexplored region of the Upper Nubra valley was surveyed by Mr. Visser and the Khan Sahib. Tributaries of the upper Shyok below Saser Brangsa were next explored, after which the expedition examined and surveyed the country east of the Karakoram pass. At the end of September Khan Sahib Afraz Gul Khan was on his way back to Leh, having surveyed approximately 13,000 square miles in this area.

Yugoslavia-Romania Boundary Commission.—Colonel W. M. Coldstream, late Director, Survey of India, has been appointed British Delegate on the Yugoslavia-Romania Boundary Commission.

The Himālayan Club, to which reference was made in last year's General Report, published its first Journal in April. It contained a summary of Central Asian and Himālayan Exploration during the previous year and many articles of interest to the Department.

Adventures and Casualties.—Officer Commanding, 'A' Company has reported the following act of gallantry by Muhammad Rafi, a porter of his company:—

On the 25th August 1928 a porter fell down a crevasse in the glacier on the Darhat Pass and lay there unconscious. The sides of the crevasse were composed of heavy brittle icicles. Muhammad Rafi descended the crevasse on a rope at considerable personal risk, and attached a rope to the unconscious man, who was then drawn up alive with some difficulty, after having been down the crevasse for over 3 hours.

U. Pe, K.S.M., A.T.M., Sub-Assistant Superintendent, and Surveyor Maung On Ba of No. 10 Party, accompanied the Civil Officer on an expedition amongst the head-hunting Nāgā Tribes in the unadministered territory to the north-west of Burma (p. 70).

Man-eating tigers and wild elephants infested the jungles under survey by No. 10 and 21 Parties; two Kachin coolies of No. 10 Party were killed by tigers (p. 71).

37 cases of cholera of which 17 proved fatal, occurred among the menial establishment of No. 21 Party (p. 75); four fatal cases of cholera occurred in No. 11 Party (p. 73). Steps are now being taken to inoculate all khalasies before proceeding to Burma on survey duty.

Two deaths from pneumonia occurred in No. 21 Party (p. 75).

New buildings.—The construction of two bungalows have been sanctioned as officers' quarters for 'E' Survey Company at Quetta.

A new map sales-room for the Map Record and Issue Office has also been sanctioned.

Unfortunately funds have not been provided, and both inconvenience and congestion, leading to loss of efficiency, are bound to occur until these buildings are constructed.

A new mural sub-standard, 100 feet long (with intermediate marks) has been constructed in the base-line alley of the Burrard Observatory at Dehra Dūn.

The following instruments were specially manufactured by the Mathematical Instrument Office for the parties specified:—

“Wheel pen” for drawing conventional signs—for the Director, Geodetic Branch, who remarked that it was a great improvement on anything hitherto tried and worked satisfactorily.

“Stand” for Furnival Hand Press with mule bags—for the Director, Frontier Circle.

“Protractor” Air Photo.—for the Ferozepore Arsenal.

An apparatus for feeding mosquitoes—for the Calcutta School of Tropical Medicine.

Twelve Slide Rules, wave length—for the Army.

One Sounding Reel to carry 300 feet wire for use with portable steel boats—for the Punjab Irrigation Branch, and one wireless Direction Finder—for the Bengal Pilot Service.

A special Duralumin Slide Rule was made for the Army and is now under test.

The Mathematical Instrument Office has completed the repair, re-cleaning and adjustment of 1,554 Prismatic Binoculars for the Director of Contracts, Army Headquarters, the Inspector of Guns, Cossipore, and a Home firm, in approximately two months.

A map mounting machine has been installed in the Map Record and Issue Office, Calcutta. This is the first machine which will be working outside England. A brief description of it is given in the Appendix.

Distinguished Visitors.—Major-General W. M. St. G. Kirke, C.B., C.M.G., D.S.O., Deputy Chief of the General Staff, Army Headquarters, India, visited the Geodetic Branch Office on the 19th October 1928.

At the invitation of the Director, the offices and parties of the Central Circle were visited by His Highness Mahārāja Sir Umaid Singh Sahib Bahadur, K.C.S.I., K.C.V.O., of Jodhpur.

Mr. A. B. Reid, I.C.S., Joint Secretary to the Government of India, Department of Education, Health and Lands, visited the headquarters offices, Calcutta, on the 29th December 1928.

Lectures and Instructions.—Colonel Phillimore, D.S.O., Director Frontier Circle, gave a lantern lecture to members of United Service Institution at Simla entitled “Recent Surveys in Swāt and neighbouring countries”. His Excellency the Commander-in-Chief in India was present.

Lt.-Colonel L. G. Crosthwait, I.A., Director, Southern Circle, delivered a lecture on “The Survey of India in Peace and War” at Poona, on the 19th and 20th September 1928.

Major Kenneth Mason, M.C., R.E., Assistant Surveyor General, delivered a lecture at the Rotary Club, Calcutta, on “Exploration in the Himalaya.”

While on leave, Captain G. H. Osmaston, M.C., R.E., enquired into the possibilities of using electric lamps for primary triangulation, instead of helios and oil lamps.

At the request of the Superintendent, Cordite Factory, Aruvankadu, Nilgiris, a chemical assistant, Mr. A. Y. Krishna Iyer of the factory was given training in the rudiments of glass blowing in the Mathematical Instrument Office for a period of one month in November-December, 1928.

An instrument maker of the Government Engineering School, Nāgpur, is undergoing training in minor repair and adjustment of surveying instruments from the 7th May 1929.

6. Appreciations. The following is an extract from the Resolutions of the Government of Assam, Revenue Department, on the Survey and Settlement Report, Assam, for the year ending the 30th September 1928 :—

"The Governor in Council takes this opportunity of acknowledging the readiness with which the officers of the Assam Survey Department have responded to all calls made upon them, and, in particular, the valuable services which Colonel McHarg, who is now on the point of retirement, has rendered to the Government of Assam throughout the period of his connection with the Department."

Letter No. 1860-R, dated 25th March 1929 from the Secretary to the Punjab Government, Revenue Department, to the Surveyor General regarding the work of No. 22 Party, is reproduced below :—

"The work of the Riverain Survey party of the Survey of India comes to a close in the Punjab this season. The Punjab Government take this opportunity of noting that the party has worked for a number of years in pursuance of the system of riverain mapping, devised by Captain E. A. Tandy, first in connection with the settlement operations in the Ludhiāna district; the work has now covered the riverain areas of the Jumna, Sutlej, Beas, Rāvi, Chenāb and Indus rivers. I am directed by the Governor in Council to say that the work of the Party has been of immense value to the Revenue Department of this Government in co-ordinating the maps made on different base lines of different villages in those difficult tracts, and in diminishing causes of disputes and litigation regarding the ownership of lands situated in the Punjab riverains."

"The Punjab Government take this opportunity, at the close of the work, of expressing their great obligations to the Survey of India for the accuracy and promptness with which the task has been discharged and for the helpful co-operation, which successive Revenue Officers in the Punjab have received from the department."

Messrs. H. Wild & Co. of Heerbrugg, Switzerland, communicated their thanks to the Mathematical Instrument Office for its constructive criticism of their new theodolites and also confirmed the Mathematical Instrument Office diagnosis of various defects which had developed in these instruments during field service.

7. Awards.—The following honours were conferred during the year :—

Knighthood	...	...	Brigadier E. A Tandy, (retired).
Rai Bahadur	...	...	Rai Sahib Pranadaranjan Ray.
Khan Sahib	...	...	Mr. Muhammad Hasan.
Kyar-thaye-zaung-Shwi-Salwe-ya-Min.			U. Pe, A.T.M.

At a durbar held at Murree on the 13th June 1929, the Commissioner of the Rawalpindi Division presented the insignia of Khan Sahib to Mr. Muhammad Hasan. The General Officer Commanding-in-Chief, Northern Command, attended the durbar.

8. Personnel.—Casualties, retirements, and recruitments were as follows:—

Class I Officers:—Brigadier E. A. Tandy, Colonels E. T. Rich, C.I.E., A. A. McHarg, D.S.O., and M. O'C. Tandy, D.S.O., O.B.E., and Messrs. W. M. Gorman and M. C. Petters, retired. Colonel C. M. Browne, C.M.G., D.S.O., died.

Major W. E. Perry, M.C., R.E., has been temporarily transferred to Security Printing, India.

Lt.-Colonel H. J. Couchman, D.S.O., M.C., R.E., reverted from the Security Printing, India, and proceeded on leave.

Lieuts. C. J. Price, R.E., R. H. Sams, B.Sc., R.E., and C. A. K. Wilson, R.E., were appointed to the Department.

Messrs. H. P. D. Morton and P. A. T. Kenny, O.B.E., F.S.I., were promoted to Superintendents.

Class II Officers. Mr. M. D. Puri, R.S., died. Mr. E. J. Biggie, retired.

Captain J. O'C. Fitzpatrick was invalided.

Messrs. Afraz Gul Khan, K.S., and Muhammad Hasan, K.S., were promoted from the Upper Subordinate to the Class II Service.

Upper Subordinate Officers. Messrs. K. K. Das, B.A., Shib Lal, R.S., and Abdul Ghafur retired, Mr. Iltifat Husain reverted from foreign service with the Air Headquarters, 'Irāq. 17 probationers were appointed, of whom one was appointed as a Geodetic Computer and seven were discharged. Three Lower Subordinates were promoted to the Upper Subordinate Service.

I.—ABSTRACT OF SURVEYS IN EACH PROVINCE AND STATE.

9. The annual expenditure on surveys in the Indian Empire must amount to something like three crores of rupees, or say two million pounds, if we include cadastral surveys, carried out locally by Provinces and States, and miscellaneous surveys for engineering projects, *e.g.*, railways, canals, mines, roads, rivers, harbours, cities, &c.

The prime duties of the Survey of India are geodetic, topographical and geographical, and cost little more than a tenth of this total (about Rs. 33,00,000); but the department is also developing co-operation with local survey agencies, with a view to mutual economy, and is now doing miscellaneous outside work costing nearly Rs. 23,00,000, on payment by those concerned, besides advising and co-operating in other directions and lending officers to Provincial Surveys as required. The following abstract shows the nature and *locale* of the field operations actually carried out by the Department during the past year, grouped under the following sub-heads:—

Air Surveys.	Riverain Surveys.
Exploration.	Boundary Surveys.
Topographical Surveys.	Geodetic.
Forest Surveys.	Framework.
Cantonment and City Surveys.	Levelling.
Cadastral Surveys.	Miscellaneous.
Railway Surveys.	Training.

10. N. W. F. Province and Kashmir.

Air surveys in Peshāwar district, tribal territory and Dir, Swāt & Chitrāl Agency (p. 46).

Topographical surveys in Hazāra district, tribal territory (Peshāwar) (p. 43).

Cadastral surveys in Dera Ismail Khān district (p. 51).

Framework. Triangulation in Dir, Swāt, Chitrāl and Gilgit Agencies (p. 43).

11. Baluchistan.

Topographical surveys in Kalāt State, Chāgai district (p. 44).

Framework. Triangulation in Kalāt State (p. 44). Traversing in Sibi district and Kalāt State (p. 44).

12. Punjab, Punjab States and Delhi.

Topographical surveys in Rāwalpindi district (p. 43).

Forest surveys in Lahore district (p. 47).

Riverain surveys in Karnāl, Rohtak, Gurgaon and Jhelum districts (pp. 47-48).

Boundary surveys in Gurgaon district (p. 41).

Framework. Traversing and rectangulation in Multān, Lahore, Muzaffargarh districts and Bahāwalpur State (p. 49).

Levelling. High precision levelling from Ghakkhar to Amritsar *via* Lahore, and from Ludhiāna to Sahāranpur. Secondary levelling from Rohillānwālī to Leiah (p. 77). Tertiary levelling in Multān, Montgomery and Muzaffargarh districts and Bahāwalpur State for rectangulation (pp. 48,50).

Special and Miscellaneous. Four-inch special irrigation surveys in Multān district (p. 48).

13. Rajputana Agency, Ajmer and Bikaner.

Framework. Triangulation in Jodhpur and Jaisalmer States (p. 44).

Levelling. High precision levelling from Nasirābād to Bina, and from Mārwar Pāli to Baroda (p. 14).

Miscellaneous. Large scale survey of Kailāna Tankin Jodhpur State (p. 56).

14. Central India Agency and Gwalior.

Topographical surveys in Rewah State (p. 55).

Levelling. High precision levelling from Nasirābād to Bina (p. 14).

15. United Provinces.

City survey of Benares (pp. 56-57). Revision at Cawnpore (p. 76).

Riverain surveys in Sahāranpur, Meerut, Muzaffarnagar, Bulandshahr and Aligarh districts (p. 48).

Boundary surveys in Bulandshahr district (p. 48).

Framework. Triangulation in Mirzāpur district (p. 54). Re-laying of traverse stations and supplementary traversing in Benares City, and traversing for revision of the Benares Guide Map (p. 57).

Traversing for Air Surveys in Sitāpur and Bahraich districts (p. 58).

Levelling. High precision levelling from Meerut to Muttra, from Dehra Dūn to Chakrātā, from Chakrātā to Mussoorie, from Kālsi to Mussoorie, and from Ludhiāna to Sahāranpur (pp. 14-15). Secondary levelling from Cawnpore to Allahābād and from Mughal Sarai to Najibābād *via* Lucknow (p. 77).

16. Central Provinces.

Topographical surveys in Bālāghāt, Bilāspur, Drug and Mandlā districts in the Chhuikhadhān, Kawardhā, Khairāgarh, Nāndgaon, Raigarh Sakti and Udaipur Feudatory States, and in the Koreā and Surgujā Tributary States (p. 55).

Cantonment and City surveys. Revision at Kamptee (p. 76).

Geodetic. Gravity at one station (p. 14).

Framework. Triangulation in Surgujā State (p. 54). In Bastar State (p. 60).

17. Bombay Presidency, States of Western India and Baroda.

Cantonment & City surveys. Revision at Poona, Kirkee & Belgaum (p. 76).

Framework. Triangulation in Bijāpur, Dhārwar and North Kanara districts and Sāngli State (p. 61). Traversing in Lārkāna and Sukkur districts and Khairpur State (pp. 55-56). Rectangulation in Nawābshāh, Hyderābād and Thar Pārkar districts (p. 55).

Levelling. High precision levelling from Bandhi to Hyderābād, and from Mārwar Pāli to Baroda (p. 14).

Miscellaneous. Survey of cave temples in Dhār State (p. 59).

18. Hyderābād.

Topographical surveys in Karimnagar, Medak, Nizāmābād and Warangal districts (p. 59).

Geodetic. Gravity at one station (p. 14).

Framework. Triangulation in Raichūr district (p. 61).

19. Mysore and Coorg.

Topographical surveys in Chitaldrug, Kadūr, Shimoga and Tumkūr districts (p. 61).

Geodetic. Gravity at one station (p. 14).

Framework. Triangulation in Shimoga and Kadūr districts (p. 61).

20. Madras Presidency and Madras States.

Topographical surveys in East and West Godāvāri, Vizagapatam, Tanjore and Trichinopoly districts; Travancore and Pudukkottai States (p. 62).

Forest surveys in East Godāvāri district (p. 60).

Special surveys. Estate surveys in Coimbatore, Malabar, Nilgiri, and Kadūr districts and Travancore State (p. 62).

Geodetic. Gravity at 15 stations (p. 14).

Framework. Triangulation in East Godāvāri, Bellary, Vizagapatam and South Arcot districts (p. 62). In Ganjām district (p. 66).

21. Bihar and Orissa.

Topographical surveys in Gayā, Palāmau, Shāhābād and Hazāribāgh districts (p. 54); in Hazāribāgh, Gayā, Balasore, Mānbhūm, Cuttack and Puri districts (p. 66); in Keonjhar and Dhenkānāl States (p. 66).

Forest surveys. Some reserved forests in the Hazāribāgh Forest Division were included in the ordinary survey (p. 65).

Cantonment and City surveys. Revision at Dinapore (p. 76).

Geodetic. Gravity at two stations (p. 14).

Framework. Triangulation and traversing in Hazāribāgh, Gayā, Patna, Monghyr, Santāl Parganas, Purnea, Cuttack, Puri and Angul districts (p. 66); in Dhenkānāl Hindol, Daspallā, Khandparā, Nayāgarh, Rānpur, Barāmbā, Athgarh, Narsinghpur and Tigiriā States (p. 66). Location and repair of stations of the old East Coast Series (p. 14).

Levelling in Gayā district (p. 65).

22. Bengal Presidency and Sikkim.

Air survey in Mālda district for Settlement surveys (p. 64).

Topographical surveys in Jalpaiguri, Rangpur and Mymensingh districts (pp. 67-68), and Cooch Behār State (p. 67).

City surveys in Calcutta (p. 66).

Forest surveys. Some reserved forests in the Jalpaiguri and Buxa Forest Divisions were included in the ordinary survey (p. 68).

Forest surveys in Chittagong district by air photography (p. 46).

Framework. Primary triangulation in Chittagong and Chittagong Hill Tracts (p. 14). Triangulation and traversing in Darjeeling, Jalpaiguri, Dinājpur, Bānkurā, Birbhūm and Burdwān districts (pp. 65, 68), Cooch Behār State and Sikkim (p. 68).

23. Assam and Bhutan.

Topographical surveys in Goālpāra, Gāro Hills, Sylhet, and Khāsi & Jaintiā Hills districts (pp. 67, 68), and Bhutān (p. 67).

Forest surveys. Some reserved forests in Goālpāra and Gāro Hills Forest divisions were included in the ordinary survey (p. 68).

Framework. Primary triangulation in the Lushai Hills (p. 68); in Cāchār and Lushai Hills districts (p. 68); in Manipur State and Bhutān (p. 68).

24. Burma, Andamans and Nicobars.

Topographical surveys in Hanthawaddy, Henzada, Insein, Pegu, Prome, Sandoway, Tharrawaddy and Thayetmyo districts and tribal territory (p. 69)

City survey in Rangoon (p. 72).

Forest surveys in Kathā, Mansi and South Pegu Forest Divisions (pp. 73, 74).

Framework. Primary triangulation in the Chin Hills and in the Southern Shan States (p. 14).

Framework in Bassein, Hanthawaddy, Insein, Ma-ubin, Myaungmya, Pegu, Pyapon, Upper Chindwin (p. 68); in Chin Hills district (p. 71).

Levelling. Secondary and tertiary levelling in the Myanaung Plain and Pegu district (p. 77).

Special surveys of a saw mill and timber yard near Rangoon (p. 73).

II.—ABSTRACT OF GEODETIC OPERATIONS

DIRECTOR:— $\left\{ \begin{array}{l} \text{Dr. J. de Graaff Hunter, M.A., Sc. D., F. Inst. P., up to 14-10-28.} \\ \text{Lt.-Colonel R. H. Thomas, D.S.O., R.E., from 15-10-28 to 13-12-28.} \\ \text{Dr. J. de Graaff Hunter, M.A., Sc. D., F. Inst. P., from 14-12-28.} \end{array} \right.$

25. General.—Besides geodetic work, the Director, Geodetic Branch, administers the following offices at Dehra Dūn; *No. 2 Drawing Office*, the *Forest and Cantonment Office* and the *Publication and Stores Office*, whose work is reported in the annual Map Publication and Office-work Report; and also the following Survey operations which are reported in other parts of this General Report:—*Levelling* carried out in aid of special engineering projects, *vide* para. 179; *Cantonment Surveys* (para. 175); *Training School* (para. 180).

26. Geodetic.—Purely geodetic operations include miscellaneous computations and research, preparation and publication of records, observatory work (astronomical, magnetic, seismological and meteorological); important series of triangulation, geodetic levelling, precise latitudes, longitudes, azimuths, and gravity determinations, in all parts of India; and prediction of tides at 38 eastern ports between Suez and Singapore.

These geodetic operations are fully described in the Annual Geodetic Report of the Survey of India. The following is a brief abstract of the geodetic operations described in the Geodetic Report for the current year, (Vol. V), which includes complete Index maps and detailed results.

Geodetic Operations for 1928-29

27. Observatory Section.—Observations were regularly taken once or twice a week with one, and occasionally with two transits. The Bordeaux and Rugby time-signals were also regularly received by day and occasionally by night. Latitude was observed once or twice a month with the zenith telescope, and gravity was measured monthly with the brass pendulums. The object of these observations is to record any change which may occur in the latitude, longitude and intensity of gravity at Dehra Dūn.

The magnetic observatory maintained its continuous record of the three magnetic elements. The Omori seismograph was in good order throughout the year and recorded 19 major and 77 minor earthquakes. Complete meteorological observations have been made daily and sent to the meteorological department, which now recognizes Dehra Dūn as one of its stations. Since 1911 Dehra Dūn had been an official meteorological station for rainfall only.

The steel tapes of the levelling party were standardized, before and after the field-season. Four sets of tapes for Hunter short bases have been standardized. A new mural sub-standard, 100 feet long with intermediate marks has been constructed in the base-line alley.

All theodolites, levels and other instruments, previously stored in the Publication and Stores Office, have been transferred to the Observatory Section, where they are more conveniently overhauled and kept in good order.

28. Computing Office.—Numerous computations have been made in connection with the Lambert grid, on which surveys will be carried out in time of war. Changes in the origin and extent of the grid have necessitated the re-computation of the tables for the conversion of spherical co-ordinates to grid. Tables and forms have been prepared for the direct computation of triangulation in grid terms without the loss of accuracy usually associated with the use of rectangular co-ordinates. A table has been prepared giving the grid co-ordinates of the corners of all 1-inch sheets, by means of which the grid may be drawn for sur-printing on maps.

Various professional forms have been revised, and new ones improvised. The compilation of the Auxiliary Tables Part IV (Geodetic) is still in hand. The editing of Geodetic Reports, Professional Papers and Departmental Papers have still given a great deal of work to the Computing Office, but the arrears of Geodetic Reports have now been overtaken.

The compilation of the Mesopotamian triangulation has been completed, and that of Persia has been begun. In all, the data of 19 degree sheets have been compiled during the year. The publication of 8 primary and 15 secondary lines of levelling has been seen through the press. The preservation and maintenance by local authorities of all protected triangulation stations and bench marks has been supervised.

29. Tidal Section.—The self-registering tide-gauges at Aden, Basra, Karāchi, Bombay, Madras, Kidderpore, Rangoon and Bassein continued to register the tides throughout the year. The gauge at Pilakat Creek at the mouth of the Rangoon River was seriously damaged by a storm on 15th July 1928, and owing to the difficulty of finding a satisfactory site, the Port authorities have decided to give up automatic registration. Instead, arrangements have been made for the times and heights of high and low water to be read on a tide-pole both by day and by night. These readings began on 16th August 1928 and have been continued since. Times and heights of high and low water have also been read, during daylight only, at Bhāvnagar, Chittagong and Akyab.

The tidal observations at Madras, Bassein, Rangoon and Kidderpore were inspected during February and March 1929. The gauge at Bassein which had been in use since 1923, was dismantled on completion of the requisite number of year's observations. The harmonic analysis is still in hand.

The preparation and publication of the 1930 tide-tables was completed by September 1929. Advance copies for 14 Indian ports were despatched to the Hydrographer to the Admiralty in February, for inclusion in the 1930 Admiralty tide-tables. The tidal curves for 1931 were run off on the tide-predicting machine between May and July 1929.

Preparations have been made to change the form of the Indian Tide-tables. Instead of numerous separate pamphlets for separate ports, it is intended to issue a combined table entitled "Tide-tables for the Indian Ocean", and to include a considerable amount of other data in addition to that of the 40 ports predicted by the Survey of India.

30. Gravity Observations.—(No. 14 Party).—Observations to determine the force of gravity were made at 2 stations in Bihār and Orissa, 15 stations in Madras Presidency, one station in Hyderābād State, one station in the Central Provinces, and one station in Mysore.

The observations were made by Major E. A. Glennie, D.S.O., R.E.

31. Triangulation.—(No. 15 Party).—Two detachments were employed on primary triangulation in Burma. No. 1 Detachment observed the angles of the Chittagong series, completing it, except for two triangles near Chittagong which had to be left over for next year. The average triangular error was $0''\cdot6$. The series runs from Chittagong, through the Lushai Hills and Chin Hills to near Falam.

No. 2 Detachment began the re-observation of the Mong Hsat series, which had previously been observed as a secondary series in 1891-93, but which is now required to form a junction between the Indian and Siamese primary triangulations. The series runs east from near Yamethin through the Southern Shan States to longitude $99^{\circ}30'$ near the junction of the Burmese, Chinese and Siamese frontiers. A meeting was arranged between the Indian and Siamese triangulators, and observations were made at three common stations. The eastern half of the series was observed, but the observations have proved defective, and will have to be rejected.

Both detachments used Wild Precision theodolites, this being the first time these instruments have been used in India. Their ease of transport and manipulation are remarkable, and the results obtained at most stations of the Chittagong series indicate that they are sufficiently accurate for triangulation of the highest class. But both the theodolites used this year have given trouble by reason of the stiffness of their vertical axes. That used for the Mong Hsat series was persistently stiff, in spite of cleaning and oiling, and is the cause of the season's work having to be rejected. That used for the Chittagong series worked freely for most of the season, but jammed tight after eleven stations, and had to be dismantled. It is hoped and expected that these theodolites will be satisfactory after this defect has been remedied.

Triangulation stations of the old East Coast series in Bihār and Orissa were located and repaired by Babu Mukhtar Ahmad, 1st Class computer, attached to No. 14 Party.

32. High Precision Levelling.—(No. 17 Party).—Out of a total length of 15,900 miles of levelling of high precision required for the new geodetic level-net of India, 735 miles were completed during 1928-29, making a total of 7,837 miles completed up to date.

During 1928-29, 1,470 miles of single levelling on the High Precision system were carried out as below:—

In fore direction only—777 miles.

Rājputāna and Central India.—Nasirābād-Bhopāl-Bina ... 433 miles.

Rājputāna and Baroda.—Mārwar Pāli-Virangām-Baroda 344 „

In back direction only—468 miles.

Punjab.—Ghakkār-Lahore-Amritsar ... 91 „

Punjab and U. P.—Ludhiāna-Ambāla-Sahāranpur ... 131 „

U. P. and Delhi.—Meerut-Delhi-Muttra ... 146 „

Śind.—Bandhi-Hyderābād (Revision) ... 100 „

In both directions.

United Provinces.—Two circuits have been completed in very hilly country viz.,—

(1) Dehra-Kālsi-Mussoorie ... $2 \times 48 = 96$ miles.

(2) Kālsi-Chakrātā-Mussoorie ... $2 \times 64\frac{1}{2} = 129$ „

Hill circuits are generally expected to give exceptionally large closing errors, and these circuits, which include heights between 1,500 and 7,000 feet, are expected to show how far such errors can be eliminated.

Reports of secondary and tertiary levelling will be found under Section X of this report (p. 77).

III.—ABSTRACT OF MAP PUBLICATION AND OFFICE WORK.

33. Full Reports of the work of all drawing, printing, and miscellaneous offices of the department, with *Index Maps* showing the progress and present state of map publication on various scales have been published separately in the *Map Publication and Office Work Report* for the financial year ending 31st March 1929. The following extracts from the full Report show the most important result of all this work, in the shape of Publications and Issues, etc.

Table I (a)—Maps published at Calcutta, during the year 1928-29.

Class of maps.	Scale.	New publica- tions.	Revised editions, new edi- tions and reprints.	Number of sheets printed.	Value Rs.
GENERAL MAPS.					
<i>Departmental.</i>					
Maps of India	Various	2	8	25,403	27,573
GEOGRAPHICAL SERIES.					
Southern Asia	1:2,000,000	...	2	545	1,390
India and Adjacent Countries ...	1:1,000,000	1	41	24,422	44,994
La Carte Internationale du Monde.	1:1,000,000	5	2	3,850	10,050
TOPOGRAPHICAL MAPS.					
Quarter-inch, Modern	1"=4 miles	17	19	16,975	25,384
" (Prely.)	Ditto	13	15	13,697	20,853
" (Provl.)	Ditto	...	22	6,676	9,868
Half-inch, Modern	1"=2 miles	39	18	29,574	63,792
" (Prely.)	Ditto	6	3	4,224	8,524
One-inch, Modern	1"=1 mile	144	108	151,009	2,23,382
" (Prely.)	Ditto	12	17	18,234	28,984
" (Provl.)	Ditto	...	1	308	308
Old-style sheets	Various	...	58	9,975	14,531
SPECIAL MAPS.					
Administration Report Maps ...	1"=8 miles	...	1	50	19
Provincial Maps	Various	...	5	3,588	7,561
Plans of Cities and Canton- ments.	Ditto	11	5	4,018	7,346
Index Maps	Ditto	5	11	15,282	5,664
Miscellaneous Maps	Ditto	24	53	62,570	22,506
Manceuvre Maps ... ..	.....	1	5	3,110	7,508
Total ... ..	.....	280	394	393,010	5,30,237
<i>Extra-departmental.</i>					
Maps	Various	261	60	137,989	29,621
Plans and diagrams	Ditto	358	11	122,625	18,657
Illustrations ... ..	.....	200	15	164,283	15,241
Miscellaneous ... ..	.....	21	39	107,280	3,741
Total ... ..	.....	840	125	532,127	67,260
Grand Total ... ..	.....	1,120	519	925,137	5,97,497

Table I (b)—Maps published at Dehra Dūn.

Class of maps.	Scale.	New publica- tions.	Reprints and new editions.	Number of sheets printed.	Value. Rs.
<i>Departmental.</i>					
Cantonment maps ...	Various	...	184	18,267	26,548
Forest maps ...	"	121	74	10,988	10,656
Miscellaneous ...	"	5	17	1,448	758
Total ...	...	126	275	25,653	37,957
<i>Extra-departmental.</i>					
Maps ...	Various	87	10	110,423	11,548
Plans and diagrams ...	"	58	10	65,026	8,047
Charts ...	"	277	...	11,151	7,262
Total ...	...	417	20	186,600	21,852
Grand Total ...	...	543	295	212,253	59,809

Table I (c)—Maps published at Bangalore.

Class of maps.	Scale.	New publica- tions.	Reprints and new editions.	Number of sheets printed.	Value. Rs.
<i>Departmental.</i>					
Cantonment maps ...	16" = 1 mile	...	16	3,180	6,860
Total ...	...	...	16	3,180	6,360
<i>Extra-departmental.</i>					
Forest maps, Hyderabad and Mysore.	Various	2	4	853	288
Private Estates ...	"	88	2	804	1,688
Plans and diagrams ...	"	2	1	2,049	284
Total ...	...	37	7	2,706	2,100
Grand Total ...	...	37	23	5,886	8,460

Table I (d)—Maps published at Quetta.

Class of maps.	Scale.	New publica- tions.	Reprints and new editions.	Number of sheets printed.	Value. Rs.
<i>Departmental.</i>					
Maps	Various	...	...	...	.....
Plans and diagrams ...	"	} 86	...	1,455	418
Charts ... ..	"		...	...	.....
Forms ... ..	"	...	...	...	.....
Total ...	...	36	...	1,455	418
<i>Extra-departmental.</i>					
Maps	Various	28	20	8,524	972
Plans and diagrams ...	"	810	...	8,745	2,194
Charts	"	5	...	2,057	512
Forms ... ..	"	...	...	...	.....
Total ...	...	338	20	14,326	3,678
Grand Total ...	...	374	20	15,781	4,096

Table I (e)—Maps published at Muree and Peshāwar.

Class of Maps.	Scale.	New publica- tions.	Reprints and new editions.	Number of sheets printed.	Value Rs.
<i>Extra-departmental.</i>					
Maps	Various	} 65	...	13,023	3,447
Plans and diagrams ...	"		...	...	.....
Charts ... ..	"	...	...	...	.....
Forms ... ..	"	...	...	...	.....
Total ...	...	65	...	13,023	3,447
Grand Total ...	...	65	...	13,023	3,447

TABLE II.—ABSTRACT OF MODERN TOPOGRAPHICAL MAPS.	One-inch sheets.	Half-inch sheets.	Quarter-inch Degree sheets.
Topographical maps published in 1928-29	156	45	80
Do. do. published in previous years.	2,575	702	205
Total published ...	2,731	747	235
Number of sheets in India ...	6,218	1,630	450

34. Notes.—Calcutta.—In addition to the work shown in Table I(a), material for the original mapping of the Eastern and Burma Circles, and for the compiled mapping of all Circles, and for numerous extra-departmental maps, was supplied. Nine indexes, in colours, for the General and Map Publication Reports and Supplement, were printed.

The work of surprinting the minute mesh on stock copies for the Army Department, which during the year involved several thousand sheets, is nearing completion.

An index divided into 100,000 yards squares showing the sheets of the 1 millionth, $\frac{1}{4}$ -inch, $\frac{1}{2}$ -inch and 1-inch series lying in part of the area covered by the new N. W. Frontier Grid Belt was published and a final Grid Guide for the preparation of grid originals throughout India is in hand.

35. Dehra Dūn.—In addition to the work shown in Table I(b) above, 58,304 prints of 977 originals, consisting of plane-table sections, triangulation charts and pamphlets, and forest maps were printed.

36. Bangalore.—In addition to the work shown in Table I(c), the Photo.-Zinc section of No. 4 Drawing Office, Bangalore, reproduced 381 plane-table sections for parties. It also prepared 488 vandyke plates. The total number of pulls in the hand presses was 17,517.

Table III.—Letterpress publications.

(a) PUBLISHED AT CALCUTTA.

1. General Report of the Survey of India, 1927-28.—(475).*
2. Do. Confidential Supplement &c., 1927-28.—(160).
3. Map Publication and Office Work Report, 1927-28.—(800).
4. Hand-book of Topography, Ch. IV, Field Traverse Table only.—(500).
5. Do. do. Ch. X, Third Edition.—(800).
6. Do. do. Ch. VI, Sixth Edition.—(1,000).
7. Survey of India Catalogue of Maps.—(2,000).
8. Do. do. (F. O. U. O.).—(400).
9. Addenda & Corrigenda for the new Map Catalogue.—(4,450).
10. Booklet of Conventional Signs.—(2,500).
11. Correction slips, to Handbooks, Type Table, Border Specimen, etc.—(28,000).
12. List of maps published, issued monthly.—(300).
13. Do. do. (F. O. U. O.), issued quarterly.—(175).
14. Survey Notes, issued monthly.—(850).
15. Government of India and Circular orders and Circular Memos. etc.—(4,070).
16. Instructions and Application forms for candidates, Class II Services.—(2,100).
17. Annual Indents for European Stores.—Various.
18. Calendar for 1929.—(8,500).
19. Price List of Survey of India maps.—(800).

* Numbers in brackets after each item denote the number of copies printed.

Table III.—Letterpress publications.—(Concl'd.).

(a) PUBLISHED AT CALCUTTA.—(Concl'd.).

20. Himalayan Library List for Simla.—(500).
21. Do. do. Dehra Dün.—(500).
22. Price List of General maps and Provincial maps.—(1,000).

(b) In hand at Calcutta.

1. Correction slips to Handbooks, Type Table, Border Specimen, etc.
2. Government of India and Circular orders, etc.
3. Miscellaneous departmental forms.

(c) PUBLISHED AT DEHRA DÜN.

1. Geodetic Report, Vol. II, 1925-26.—(450).*
2. Records of the Survey of India Vol. XXII., Exploration of the Shaksgam Valley and Aghil Ranges, 1926.—(500).
3. Accounts Pamphlet.—(800).
4. Auxiliary Tables Part III.—(500).
5. Hand-book of Levelling.—(810).
6. Tide Tables for Indian Ports, 1929.—(6,840).
7. Investigations regarding Gravity and Isostasy (Revised and completed by Major C. M. Thompson).—(105).
8. 8 Levelling Pamphlet Addenda No. 84.—(75 of each).
9. Secondary Levelling Lines.—(200 of each).
10. 8 Secondary Levelling Lines.—(100 of each).
11. 5 Triangulation Pamphlets.—(100 of each).
12. 8 Do. do. Addenda.—(100 of each).
13. Qualification Report Form for Lower Subordinates.—(800).
14. 8 Captions for Museum exhibits.—(10 of each).
15. Annual Indent for European Stores.—(25).
16. Periodical returns for Central Circle 28 pp.—(50 of each).
17. Distribution list of Geodetic Report.—(25).
18. Do. do. Publications.—(80).
19. List of Publications (letterpress) Survey of India.—(150).
20. Notes on Air Survey in Egypt.—(15).
21. Minutes of the 4th meeting of the Indian Air Survey Committee.—(40).
22. Correction slips to Accounts Pamphlet.—(800).
23. 8 Additional pages of Auxiliary Tables Part III.—(50).
24. 14 Correction slips to Handbook of Levelling.—(810).
25. 8 Correction slips to Topography, Ch. III.—(800 of each).
26. Correction slips to Irrigation Surveys and Settlement Project.—(410).
27. Do. to G. T. S. Volumes XVIII.—(800).
28. 10 Do. to Forest Map Office Catalogue.—(800 of each)
29. 5 List of Bench-marks.—(8 of each).
30. Lists for the Mussoorie Guide map.—(8).
31. 126 Professional forms.—(11,644).
32. 509 Miscellaneous jobs.—(17,325).
33. Hunter Short Base.—(100).

(d) In Hand at Dehra Dün.

1. Geodetic Report, Vol. III, 1926-27.
2. Do. Vol. IV, 1927-28.
3. Tide Tables, for Indian Ports for 1930.
4. Professional Paper 22 (Three sources of error in Precise Levelling).
5. Do. do. 23 (Air Survey in Waziristan, 1923 to 28).
6. Levelling Pamphlet No. 53.
7. 5 Levelling Pamphlets, Addenda.
8. 4 Triangulation Pamphlets.
9. 9 Secondary Levelling Lines.
10. Reference for U. P. Road Maps.

In addition to the work shown above P. O. Binding Section has bound library books and registers (8,200) 44 photosincographed Triangulation pamphlets (4,400) pasted correction slips (1,587) maps folded (5,377) and forms ruled (17,683).

* Numbers in brackets after each item denote the number of copies printed.

37. Map Issues.—The following Table shows the number of maps issued during the year.

Table IV.—Maps issued by Survey units.

D = Departmental X = Extra-departmental.		ON BOOK TRANSFER (TO GOVERNMENT OFFICIALS).		ON CASH PAYMENT.		FREE ISSUES.		TOTAL.	
		Number of copies.	Sale Value. Rs.	Number of copies.	Sale Value. Rs.	Number of copies.	Face Value. Rs.	Number of copies.	Sale Value. Rs.
Calcutta	D	50,672	71,012	72,083	79,083	74,323	107,227	197,078	1,50,095*
	X	383,893	50,951	141,100	20,797	15,014	3,409	540,007	71,748*
Dehra Dūn	D	23,175	20,151	2,503	3,678	24,208	38,542	49,886	23,829
	X	146,069	33,397	5,862	5,794	50	150	151,981	39,191*
Simla	D	11	16	34	89	.....	.....	45	105
Rāwalpindi ("A" Company)	D	.....	.....	1	2	.....	.....	1	2
Quetta ("E" Company)	D	.....	.....	44	71	6	9	50	80
	X	10,006	2,712	4,320	966	.....	.....	14,326	3,678
Peshāwar (No. 18 Party)	D	.....	.....	.....	11	.....	.....	7	11
	X	2,211	309	10,792	3,133	20	5	13,023	3,447
Mussoorie	D	.....	.....	185	407	.....	.....	185	407
Bangalore	D	1,848	3,084	† 5,620	11,713	.....	.....	† 7,468	14,797
	X	.....	.....	2,693	493	.....	.....	2,693	493
Shillong	D	.....	.....	602	1,138	.....	.....	602	1,138
Maymyo	D	560	880	487	880	.....	.....	1,047	1,760
Totals ...		618,445	182,512	246,333	128,255	113,621	149,342	978,399	3,10,781

* These figures do not include the value of free issues.

† Includes 17 Map Catalogues and 1 Imperial Atlas.

38. Map Record and Issue Office:—The total number of departmental maps issued increased by 4,874, but the proceeds decreased by Rs. 25,427. The figures for extra-departmental maps decreased by 50,051 in issues and Rs. 12,677 in proceeds.

Two of the main contributory causes for the apparent decreases are the much smaller sums now at the disposal of the military authorities for the purchase of maps and the reduction in price from July 1928 of 1/4-inch maps and the 1/2M Layered and Political editions. The much more

important reason is, however, the introduction of a new and more accurate method of calculating the results of the year's working. Hitherto the figures included large numbers of maps which had been ordered, but were not actually issued at the close of the financial year.

By the system now adopted the figures show only actual issues. If the calculations were based on the old method, the number of copies of departmental maps issued would show an increase on book debit of 1,284, and on cash payment of no less than 16,174.

It may be noted that owing to the general reorganisation of the office, which is now being carried out, so far there has been little opportunity to concentrate upon up-to-date methods of increasing sales. In spite of this, figures for the last quarter are satisfactory.

124 new steel almirahs with a capacity of 1,736 shelves were erected during the year. With the erection of 41 more steel almirahs, in the immediate future, the modern storage accommodation for published maps will be completed. The provision of similar storage accommodation for originals and records will then be taken in hand and it is hoped to finish this work within the next two years.

A Map Mounting Machine, of the type in use at the Ordnance Survey Office in Southampton, has been ordered from England. This machine ought to materially reduce the cost of mounting and greatly speed up the work. One of the probable results of its installation will be the adoption of the policy of stocking mounted maps, instead of only paper copies as at present.

39. Stock of Maps.—Calcutta. Probably for the first time, a proper and systematic stock-taking has been carried out of all published maps stored in the Map Record and Issue Office, except for certain old-style miscellaneous maps which are still being counted. With this exception the stock, as it stood on the 31st March 1929, is given in the table below.

With the introduction of a new form of ledger, the figures of the stocks in hand will be available in future at any time.

Maps.	Number of copies in stock.	Present Face Value Rs.
1/2M Southern Asia Series ...	6,737	17,589
1/M India and Adjacent Countries ...	45,118	89,184
1/M Carte Internationale du Monde ...	5,656	16,866
One-inch sheets ...	1,063,285	16,11,312
Half-inch sheets ...	292,643	5,96,119
Quarter-inch sheets ...	246,574	3,82,276
General Maps of India ...	15,081	24,628
Provincial Maps of India ...	5,611	19,889
Cantonment and Town Maps ...	46,790	1,35,616
Miscellaneous Maps ...	36,891	75,142

Dehra Dūn. A comparison of Table I (b) with Table IV shows that, during the year, 212,253 sheets were published, and 201,867 sheets issued. Stocks in hand have increased by 10,386 (543 new maps). The total stocks in hand in Dehra Dūn are estimated at 347,283 (including 3,820 sheets received from Calcutta).

Bangalore.—The stock of maps on 31st March 1929 was as follows.—

1-inch, $\frac{1}{2}$ -inch, $\frac{1}{4}$ -inch and 1/M series 86,848 sheets, value	Rs. 58,150
Miscellaneous maps 4,813 sheets, value	7,778
Total 40,661 sheets, value	65,928

All have been now arranged and card indexed.

40. Mathematical Instrument Office.—The demands on the office for the repair of instruments and the workshop outturn show a considerable increase compared with recent years (*vide* 2 and 6 in the following Table). Demands by Public Works Department, Military and Railways were unusually high.

<i>Up to 31st March 1929.</i>	1926-27.	1927-28.	1928-29.
	<i>Rs.</i>	<i>Rs.</i>	<i>Rs.</i>
1. Total value of stores issued ...	5,17,410	5,60,829	5,39,308
2. Value of repairs carried out to order ...	1,40,144	1,54,092	2,44,069
3. Value of instruments, etc., returned to Store by those who no longer require them	99,369	63,760	32,356
4. <i>Book Value of Stock</i>			
(a) In Serviceable Store	2,48,669	2,87,839	3,09,675
(b) In Repairable Store	80,559	97,799	96,260
(c) In Material Store	1,94,132	2,01,072	2,02,847
5. <i>Value of New Instruments</i>			
(a) Manufactured in Workshops ...	2,40,642	2,92,781	1,90,821
(b) Purchased locally	83,016	93,964	46,893
(c) Imported through the Stores Department, London ...	1,82,919	2,47,624	2,20,876
6. <i>Workshops</i>			
(a) Value of work done	4,71,518	5,49,208	5,76,546
(b) Cost of employees (including pension contribution) ...	1,70,980	1,76,572	1,93,538
(c) Average number of employees ...	No. 458	No. 461	No. 480

IV.—ABSTRACT OF TOPOGRAPHICAL WORK

41. The following Tables show the progress of the topographical programme assigned to the Department in 1905 and the out-turns and cost-rates of different parties during the year under report.

42. Progress. It was hoped in 1905 that maps on the scale 1-inch = 1 mile would be available for the whole Indian Empire within 25 years; but the work has been greatly retrenched and delayed from various causes, and in 1913 the Secretary of State sanctioned a scheme for the reduction of the scale of survey in the less populous areas. Allowing for the surveys to be carried out on the reduced scales of $\frac{1}{2}$ -inch and $\frac{1}{4}$ -inch = 1 mile, under this scheme, we may roughly regard half the work as being completed by 1925; though there is a tendency to revert to the 1-inch = 1 mile scale in special cases owing to the pressing requirements of geologists and engineers, combined with the modern military view that this is the smallest scale suitable for tactical operations. Table B gives an idea of the work ahead according to present policy, and the state of the work is shown in the *Index Map* at the end of this volume.

Revision of modern surveys has also become necessary in some important frontier tracts and is already much needed in some other areas. Also some areas surveyed on smaller scales have had to be re-surveyed on a larger scale. The figures for this work are given in italics at the end of Table A.

Table A.—Progress of Topographical Surveys since 1905.

Scales of survey mostly 1-inch = 1 mile, but including a good deal of $\frac{1}{2}$ -inch work, and some $\frac{1}{4}$ -inch occasionally.

Survey years.	Old Northern Circle.	Old Southern Circle.	Old Eastern Circle.	TOTALS.
	<i>Sq. miles.</i>	<i>Sq. miles.</i>	<i>Sq. miles.</i>	<i>Sq. miles.</i>
1905-10 ...	70,784	44,675	52,885	168,344
1910-15 ...	116,958	70,765	51,654	289,377
1915-20 ...	88,718	59,916	40,654	184,288
1920-25 ...	82,777	106,619	66,708	256,099
Totals to 1925 ...	304,232	281,975	211,896	798,103

The Burma Circle was separated from the Eastern Circle in 1922-23. The Northern and Southern Circles were reformed as three Circles in 1925-26. The above totals are therefore redistributed amongst the present five Circles as follows (with slight adjustment based on revised estimates):—

Table A.—*Conold.*

Survey years.	Frontier Circle.	Central Circle.	Southern Circle.	Eastern Circle.	Burma Circle.	TOTALS.
	<i>Sq. miles.</i>	<i>Sq. miles.</i>	<i>Sq. miles.</i>	<i>Sq. miles.</i>	<i>Sq. miles.</i>	<i>Sq. miles.</i>
Up to 1925 ...	172,882	218,774	200,051	89,587	122,809	798,108
1925-26 ...	4,906	11,621	14,187	6,029	6,012	42,705
1926-27 ...	7,964	6,086	13,753	10,889	5,543	44,185†
1927-28 ...	6,297	4,085	14,840	14,178	7,897	47,242
1928-29 ...	8,306	3,952	14,008	14,089*	7,533	47,888
	199,855	239,418	256,789	134,767	149,294	980,123
<i>Balance re- maining.</i>	331,760	198,582	86,761	150,468	116,581	884,152
Total pro- gramme.	531,615	438,000	343,550	285,235	265,875	1,864,275†

Revision and Re-survey of the above work.

<i>Up to 1928 ...</i>	5,104	284	2,750	70	1,016	9,224
	280	Nil	23	Nil	108	806

* Includes 1,355 square miles surveyed by No. 1 Party Central Circle.

† Excludes 54,995 square miles, surveyed in Nepal on the $\frac{1}{4}$ -inch = 1 mile scale.

Table B.—Analysis of balance remaining on 1st October 1929.

Proposed scale of survey.	Frontier Circle.	Central Circle.	Southern Circle.	Eastern Circle.	Burma Circle.	TOTALS.
	<i>Sq. miles.</i>	<i>Sq. miles.</i>	<i>Sq. miles.</i>	<i>Sq. miles.</i>	<i>Sq. miles.</i>	<i>Sq. miles.</i>
1 $\frac{1}{4}$ -inch & over	46,888	Nil	Nil	Nil	Nil	46,888
1-inch ...	54,569	48,185	86,761	102,880	97,587	384,982
$\frac{1}{2}$ -inch ...	200,692	148,789	Nil	47,588	18,994	416,018
$\frac{1}{4}$ -inch ...	29,616	6,658	Nil	Nil	Nil	36,274
Totals.	331,760	198,582	86,761	150,468	116,581	884,152

Table C.—Areas and Cost rates of Surveys, 1928-29.

PARTY AND LOCALITY.		Area in sq. miles (in- cluding descrip- tion of work.	Cost rate per sq. mile (in- cluding computa- tions and mapping).	Total area of Topo- graphical Survey.	Total ex- penditure October 1st 1928 to Sept. 30th 1929.	Overall cost rate of Topo- graphical Survey.	REMARKS.
Character of country.	Scale and description of work.						
"A" Company.—Punjab, North-West Frontier Pro- vince and Kashmir.							
Bare snow clad mountain ranges, Quarter-inch deep valleys, (7,000 to 20,000 ft.).		4,850	21'8 ^(b)				FRONTIER CIRROLE. (a) Summer Programme 1928 completed after 30th September 1928. (b) Cost rates for summer season 1928 not reported last year, based on total area surveyed during the season. (c) Cost rate not yet avail- able. (d) Superadded cost rate reported last year and is based on total area surveyed during the summer season. Sur- vey by men under ins- tructions. (e) Includes Rs. 16,873 cost of Military escorts, debtiable to Army esti- mates. (f) Approximate. Recon- naissance of 1,045 miles completed and obser- vation stopped by haze. (g) Observation only. Re- connaissance completed in 1927-28. (h) This figure represents the area actually trian- gulated and not the complete area of 40 N and O. Sufficient points already existed in part of sheet 40 N. (i) Includes cost of drawing of Hareli Sheets.
Ditto		560	...				
Ditto		245 ^(a)	23'6 ^(b)				
Ditto		289 ^(a)	...				
Ditto		2,901	...				
Ditto		257 ^(a)	58'8 ^(b)				
Ditto		710	57'1				
Ditto		300	28'0				
Ditto		43	.....			
Ditto		85	207'0				
Ditto		51	132'8 ^(d)	5,394	2,53,877	47'0	
Ditto and wooded hills Four-inch		23	.....			
Plains with deep ravines		...	1/13833				
"E" Company.—Baluchistan & Rajputana Agency— (Kalat state & Chagai District) (Jodhpur & Jaisalmer states).							
Bare rugged hills rising from open One-inch plateau.		520 ^(f)	10'3				
Ditto		1,054 ^(g)	12'9				
Low sand hills, desert and sparse cultivation.		7,899 ^(h)	2'7				
Very difficult rugged hills		1,300	54'8				
Bare rugged hills rising from open One-inch plateau.		1,040	39'6				
Ditto		1,054	44'4	3,394	2,48,192	71'7	
No. 23 Party.—Punjab.							
Hareli Irrigation surveys Cultiva- tated plains and desert country with scrub jungle.		285	121'5 ⁽ⁱ⁾	235	28,552	121'5 ⁽ⁱ⁾	

Table C.—Areas and Cost rates of Surveys, 1928-29.

PARTY AND LOCALITY.		Area in sq. miles of each description of work.	Cost rate per sq. mile (including computations and mapping).	Total area of Topographical Survey.	Total expenditure October 1st 1928 to Sept. 30th 1929.	Overall cost rate of Topographical Survey.	REMARKS.
Character of country	Scale and description of work.						
No. 1 Party.—United Provinces & Central Provinces.							
<i>Thickly forested hills</i>	... One-inch Triangulation	1,362	6'6				CENTRAL CIRCLE.
Bihar & Orissa and Central Provinces.							
<i>Hills covered with thick jungle, cultivated valleys and some plains.</i>	One-inch Re-survey	2,279	20'0	2,279	90,163	39'6	
No. 5 Party.—Central Provinces & Central India.							
<i>Densely wooded hills and plains</i>	One-inch Triangulation	4,847	5'6				
Central Provinces.							
<i>Cultivated plains</i>	... One-inch Traverse	48'9 (Linear miles).	35'0				
<i>Chiefly heavily wooded hills</i>	... One-inch Original survey	2,142	27'6		(e) 1,07,816	35'6	
	One-inch Supplementary survey	886	12'1	3,028			
Benares Detachment.—United Provinces.							
<i>The congested portion of Benares City and the somewhat open area on outskirts.</i>	Sixty-four & Supplementary	50 (Linear miles).	120'2 per linear mile.		6,009		
	Sixteen-inch Original survey	2,165 Acres.	30'01 per acre.		65,127	30'08	
	Sixteen-inch Original survey	1,862 Acres.	8'07 per acre.		6,839	8'67	

Table C.—Areas and Cost rates of Surveys, 1928-29.

PARTY AND LOCALITY. Character of country.	Area in sq. miles in each description of work.	Cost rate per sq. miles including computations and mapping.	Total area of Topographical Survey.	Total expenditure October 1st 1928 to Sept. 30th 1929.	Overall cost rate of Topographical Survey.	REMARKS.
<p>Benares Detachment.—United Provinces.</p> <p><i>Area of environs of Benares City, Six-inch</i> Traversing ...</p> <p><i>fairly open.</i></p> <p>Rajputana.</p> <p><i>Partly open and partly wooded</i> Sixteen-inch Original survey ...</p> <p>Air Survey Traverse Detachment.—United Provinces.</p> <p><i>Partly open and well cultivated Sixteen-inch</i> Traversing for con-</p> <p><i>plains interspersed with nu-</i> trol of Air Surveys.</p> <p><i>merous villages and mango</i></p> <p><i>groves, and partly intricate</i></p> <p><i>ravines covered with high grass</i></p> <p><i>and scrub, along the Gumti</i></p> <p><i>and Gogra rivers.</i></p>	<p>78 (Linear miles).</p> <p>389 Acres.</p> <p>3,796 (Linear miles).</p>	<p>Ra.</p> <p>57'07 per linear mile.</p> <p>5'7 per acre.</p> <p>14'8 per linear mile.</p>	<p>Sq. m.</p> <p>4,508</p> <p>2,096</p> <p>89,788</p>	<p>Ra.</p> <p>5'68</p>	<p>Ra.</p>	<p>CENTRAL CIRCLE.—Conold.</p>

Table C.—Areas and Cost rates of Surveys, 1928-29.

PARTY AND LOCALITY.		Character of country.	Scale and description of work.	Area in sq. miles of each description of work.	Cost rate per sq. mile (including computations and mapping).	Total area of Topographical Survey.	Total expenditure October 1st 1928 to Sept. 30th 1929.	Overall cost rate of Topographical Survey.	REMARKS.
No. 6 Party.—Hyderābād and Madras.									
Jungle-clad high hills with open cultivated plains.		One-inch	Triangulation	3,250	5'1				
Open cultivated plains		One-inch	Traversing	97	58'0				
Low forest-clad hills and open cultivated plains.		One-inch	Original survey	4,245	15'9				
Ditto.		One-inch	Supplementary survey	235	4'3				
Intricate hills covered with thick forest and undulating ground with cultivated patches.		Two-inch	Original survey	394	58'3				
Special Works.									
A typical Indian cantonment (of Bangalore).		Sixteen-inch	Revision survey	...					
Caves in Western India for Guide Maps.		.....		...		
Mandu Fort		Four-inch	Survey	...					
Fair Mapping		4-inch		4,508	1'8				
Ditto		2-inch		597	15'3				
Ditto		1 1/2-inch		4,878	5'1				
No. 7 Party.—Bombay, Hyderābād, Madras & Mysore.									
Open undulating cultivated plain at about 2,000 feet with low bare hills; and densely wooded plateau and ranges about 3,000 feet.		One-inch	Triangulation	4,014	2'9				
Undulating plateau at 3,000 ft. varying from open cultivation to heavily wooded low hills and ranges rising to 6,000 feet.		One-inch	Original survey (Madras)	5					
Tea and coffee Estates		One-inch	Supplementary survey (Mysore)	4,914	19'4				
		Sixteen-inch	Original survey	1,106	1'14				
				acres or 1'7 sq. miles.					
						4,921	1,09,397	22'2	
(*) Excludes cost of cave surveys and other extra-organizational work, viz., Rs. 11,486.									

Table C.—Areas and Cost rates of Surveys, 1928-29.

PARTY AND LOCALITY.		Area in sq. miles of each descrip- tion of work.	Cost rate per sq. mile (in- cluding computa- tions and mapping).	Total area of Topo- graphical Survey.	Total ex- penditure October 1st 1928 to Sepor- t 30th 1928.	Overall cost rate of Topo- graphical Survey.	REMARKS.
Character of country.		Scale and description of work.		Sq. m.	Rs.	Rs.	EASTERN <u>CIRCLE.</u>
No. 4 Party.—Bengal, Bihar and Chota Nagpur.							
Wooded hills and open plains with isolated hills.	One-inch	Triangulation	...	1,118	6'4		
Open cultivated plains with patches of jungle.	One-inch	Traverse	...	2,360	9'5		
Cultivated plains with palm and other trees.	One-inch	Levelling	...	180	6'0		
Wooded hills and plains and open cultivated plains.	One-inch	Supplementary survey	...	3,888	26'9	1,84,215	
No. 9 Party.—Orissa.							
Dense wooded ranges with narrow cultivated valleys.	One-inch	Triangulation	...	4,147	5'3		
Flat cultivated plains intersected by numerous rivers.	One-inch	Traverse	...	1,398	8'5		
Wooded and isolated hills, cultivated plains and swamp areas along coast.	One-inch	Original survey	...	3,962	28'4	1,46,876	
No. 12 Party.—Assam, Bhutan and Bengal.							
Plains, partly open, but largely covered with high grass, Sal, Simul and bamboo jungle and in Bhutan, densely wooded, steep hills.	One-inch	Triangulation	...	1,400	9'6		(a) Excludes cost of Calcutta Town Survey of Rs. 1,966 but includes cost of training of pupils.
	One-inch	Traverse	...	2,100	6'6		
	One-inch	Original survey	...	547	15'2		
	One-inch	Supplementary survey	...	2,548	24'3	1,64,807	
	Half-inch	Triangulation	...	2,100	8'2		
Densely wooded hills	Half-inch	Original survey	...	1,839	7'5	38'3	

Table C.—Areas and Cost rates of Surveys, 1928-29.

PARTY AND LOCALITY.		Area in sq. miles of each description of work.	Cost rate per sq. mile including computations and mapping).	Total area of Topographical Survey.	Total expenditure October 1st 1928 to Sept. 30th 1929.	Overall cost rate of Topographical Survey.	REMARKS.
Character of country.	Scale and description of work.						
No. 10 Party.—Lower Burma.							
High hills and wooded valleys ...	Half-inch	1,543	5'2	4,386	2,15,781	48'6	(a) Includes Rs. 44,543 debitable to Burma Government, P. W. D., Irrigation Branch.
Hills covered with dense jungle	One-inch	2,520	52'0				
Cultivated plains with patches of thick grass.	Four-inch	323	229'6				
No. 11 Party.—Lower Burma.							
Densely wooded hills	...	600	11'2	3,014	1,86,478	61'9	(b) Includes Rs. 14,388 debitable to Burma Government, but excludes Rs. 9'0 recovered for the survey of a saw mill. The whole cost is debitable to the Burma Government, Forest Department.
Cultivated tidal delta	...	621 (Linear miles).	58'4 (per linear mile).				
Sand and mud flats	...	98	35'6				
Cultivated plains	One-inch	55	34'8	236	2,17,577	922'0	
Cultivated plains and densely wooded hills.	One-inch	2,840					
Cultivated plains	...	88					
Densely wooded hills (Forest Reserves)	Two-inch	45	277'0	154	187'6		
Town and suburbs of Rangoon	Four-inch	45					
	Four-inch	3					
No. 21 Party.—Upper Burma—Reserved forests.							
	Four-inch	600	87'7	236	2,17,577	922'0	
	Four-inch	215 (Linear miles).	126'2 (per linear mile).				
Steep and low densely wooded hills.	Four-inch	286	652'1				

Table C.—Areas and Cost rates of Surveys, 1928-29.

PARTY AND LOCALITY.		Area in sq. miles of each description of work.	Cost rate per sq. mile (including computations and mapping).	Total area of Topographical Survey.	Total expenditure May 1st 1928 to March 31st 1929.	Overall cost rate of Topographical Survey.	Remarks.
Character of country.	Scale and description of work.						
No. 20 Forest & Cantonment Office.							
<i>Cantonments in Bombay, Central Provinces, United Provinces and Bihar & Orissa.</i>	16-inch	Traversing	...	164.1 (Linear miles).	5 per linear mile.	Rs.	GEODETIC BRANCH. (a) Excludes Rs. 15,481 on account of expenditure on mapping, but includes pay for March 1929.
	64-inch	Traversing	...	42.3 (Linear miles).	57 per linear mile.	Rs.	
	16-inch	Levelling	...	97.2 (Linear miles).	19 per linear mile.	Rs. 58,832 (a)	
	16-inch	Original survey	...	2.5 sq. miles.	569 per sq. mile.		
	16-inch	Revision survey	...	28.3 sq. miles.	1,300 per sq. mile.		
	64-inch	Revision survey	...	0.2 sq. miles.	23 per acre.		
<i>Congested basār areas on 64-inches = 1 mile scale.</i>							
<i>Cantonment areas on 16-inches = 1 mile scale.</i>							
<i>Note:—Figures refer to Poona, Kirkee, Belgaum and parts of Kamptee and Cawnpore.</i>							

Table D.—Average monthly out-turns, 1928-29.
out-turns are given for surveyors (excluding pupils and men under training) for a month of 24 working days.

PARTY.	LOCALITY.	PLANETABLING.												TRIANGULATION.				TRAVERSING.				MISCELLANEOUS.				REMARKS.	
		1-INCH.		1 1/2-INCH.		2-INCH.		4-INCH.		1 INCH INCH.		1 INCH INCH.		1 INCH INCH.		1 INCH INCH.		1 INCH INCH.		1 INCH INCH.		1 INCH INCH.		1 INCH INCH.			
		Original or re- vision survey.	Supplementary or revision survey.	Original or re- vision survey.	Supplementary or revision survey.	Original or re- vision survey.	Supplementary or revision survey.	Original or re- vision survey.	Supplementary or revision survey.	Original or re- vision survey.	Supplementary or revision survey.	Original or re- vision survey.	Supplementary or revision survey.	Original or re- vision survey.	Supplementary or revision survey.	Original or re- vision survey.	Supplementary or revision survey.	Original or re- vision survey.	Supplementary or revision survey.	Original or re- vision survey.	Supplementary or revision survey.	Original or re- vision survey.	Supplementary or revision survey.	Original or re- vision survey.	Supplementary or revision survey.		
1.	2.	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	FRONTIER CIRCLE.— Concl'd. (e) Reconnaissance and Observations (f) Owing to very dense forest along the river Indus the out- turn of travers- ing and rect- angulation has been below ave- rage during the year under report. 201. G	
"E" Com- pany.	Jodhpur and Jaisalmer state.	Square miles.												Square miles.				Linear miles.									(f) 15 1/2 linear miles
						
		...												(e) 780				...				...
No. 23 Party.	Punjab	...	...	...	...	...	...	...	...	...	14	15	...	...	...	...	...	...	...	...	...	...	...	...	No. of sta- tions ob- serv- ed 1433
Settle- ment Survey Detach- ment.	Indus riverain area Dera Ismail Khān district.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...

Table D.—Average monthly out-turns, 1928-29.

All out-turns are given for surveyors (excluding pupils and men under training) for a month of 24 working days.

PARTY.	LOCALITY.	PLANETABLING.										TRIANGULATION.				TRAVERSING.					MISCELLANEOUS.			REMARKS.		
		1-INCH.		1-INCH.		1-INCH.		1-INCH.		1-INCH.		1-INCH.		1-INCH.		1-INCH.		1-INCH.		1-INCH.		1-INCH.			1-INCH.	
		Original or revision survey.	Supplementary or revision survey.	Original or revision survey.	Supplementary or revision survey.	Original or revision survey.	Supplementary or revision survey.	Original or revision survey.	Supplementary or revision survey.	Original or revision survey.	Supplementary or revision survey.	Original or revision survey.	Supplementary or revision survey.	Original or revision survey.	Supplementary or revision survey.	Original or revision survey.	Supplementary or revision survey.	Original or revision survey.	Supplementary or revision survey.	Original or revision survey.	Supplementary or revision survey.	Original or revision survey.	Supplementary or revision survey.		Original or revision survey.	Supplementary or revision survey.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24			
No. 1.	Bihar & Orissa & Central Provinces.	...	...	45	...	...	...	...	...	...	...	...	Sq. miles.	...	...	...	...	...	...	...	...	...	...	...	...	...
No. 5.	Central Provinces & Central India.	...	...	32	99	...	...	...	...	...	...	...	...	407	...	...	...	...	27	...	...	...	...	...	...	...
Bena- res Detach- ment.	Benares City & Environs.	...	...	...	...	...	...	...	...	...	...	1862	2165	...	...	...	...	...	...	50*	78	...	...	...	...	...
Air Survey Traverse Detach- ment.	Jodhpur (or Marwar) State, Rajputana.	...	...	...	...	...	...	...	...	...	369	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
	Districts Sitapur & Bahraich of United Provinces.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	98*	45*	...	...	...	...	...	...	...	...	...

* Supplementary traversing.

* Post-pointing.

Table D.—Average monthly out-turns, 1928-29.

All out-turns are given for surveyors (excluding pupils and men under training) for a month of 24 working days.

PARTY.	LOCALITY.	PLANETABLING.												TRIANGULATION.				TRAVERSING.					MISCELLANEOUS.			REMARKS.
		1-INCH.		1½-INCH.		2-INCH.		4-INCH.		1-INCH.		1½-INCH.		1-INCH.		1½-INCH.		1-INCH.		1½-INCH.		1-INCH.		1½-INCH.		
		Original or re-survey.	Supplementary or revision survey.	Original or re-survey.	Supplementary or revision survey.	Original or re-survey.	Supplementary or revision survey.	Original or re-survey.	Supplementary or revision survey.	Original or re-survey.	Supplementary or revision survey.	Original or re-survey.	Supplementary or revision survey.	Original or re-survey.	Supplementary or revision survey.	Original or re-survey.	Supplementary or revision survey.	Original or re-survey.	Supplementary or revision survey.	Original or re-survey.	Supplementary or revision survey.	Original or re-survey.	Supplementary or revision survey.	Original or re-survey.	Supplementary or revision survey.	
1		3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	<u>EASTERN CIRCLE</u>		
No. 4	Bengal, Bihar and Chotā Nagpur.	...	...	...	39	...	...	...	...	...	...	...	Sq. miles.	...	313	...	63	...	Linear miles.	...	...	...	...
No. 9	Orissa	31	...	...	...	...	...	...	...	...	...	...	...	439	...	...	68	...	...	...	...	...	...
No. 12	Assam, Bhutan and Bengal.	101	...	37	25	...	...	...	...	...	...	...	1229	216	...	...	62	...	...	...	...	...	...

Table D.—Average monthly out-turns, 1928-29.
All out-turns are given for surveyors (excluding pupils and men under training) for a month of 24 working days.

PARTY.	LOCALITY.	PLANETABLING.												TRIANGULATION.				TRAVERSING.				MISCELLANEOUS.				REMARKS.
		1-INCH.		1½-INCH.		2-INCH.		4-INCH.		For 1-inch survey.	For 1½-inch survey.	For 2-inch survey.	For 4-inch survey.	Main Circuits.	For 1-inch survey.	For 1½-inch survey.	For 2-inch survey.	For 4-inch survey.	For 1-inch survey.	For 1½-inch survey.	For 2-inch survey.	For 4-inch survey.				
		Original or re-survey.	Supplementary or revision survey.	Original or re-survey.	Supplementary or revision survey.	Original survey.	Original survey (Forest).	Original survey (Town Guide).																		
1	2	3	4	5	6	7	8	9	10	11	12	13		14	15	16	17	18	19	20	21	22	23	24		
No. 10	Lower Burma	(a) 142	...	...	38	...	...	...	6	...	...	...	Sq. miles.	...	...	...	...	Linear miles.	...	...	...	...	...	...	<u>BURMA CIRCLE.</u> (a) On Transfrontier Expedition.
No. 11	Lower Burma	...	...	102	47	28	27	11	3	5	...	...	Sq. miles.	...	496	...	...	44	18	...	...	...	...	...
No. 21 (Burma Forest).	Upper Burma Reserved Forests.	...	...	...	...	...	...	...	2	...	...	...	Sq. miles.	...	...	239	...	...	18	...	...	...	...	...	Includes 520 sq. miles unclassified forests, and includes pupils and surveyors planning for short periods.

Table D.—Average monthly out-turns, 1928-29.

All out-turns are given for surveyors (excluding pupils and men under training) for a month of 24 working days.

PARTY.	LOCALITY.	PLANETABLING.				TRIANGULATION.				TRAVERSING.				REMARKS.
		16 INCH.	64 INCH.	16 INCH.	16 INCH.									
1	2													24
No. 20 Forest & Cantt. Office.	Bombay, Cen- tral Provinces, United Pro- vinces and Bihar & Orissa.													
		22214	213	4433*										

V.—SURVEY REPORTS, FRONTIER CIRCLE

DIRECTOR:— { Colonel S. W. Sackville Hamilton, D.S.O., R.N., to
21-10-28.
Colonel R. H. Phillimore, D.S.O., R.N., from 22-10-28.

43. Summary.—The units administered by the Frontier Circle were "A" and "E" Companies, Nos. 18, 22 and 23 Parties, the Settlement Survey Detachment and No. 6 Drawing Office.

As neither the Punjab nor the North-West Frontier Province Government had any more revenue surveys to be done, the Settlement Survey Detachment was disbanded on 5th February. This detachment had been formed in June 1924 under Rai Sahib Maya Das Puri, and had done valuable work in Attock and Peshawar Districts.

The department has suffered a great loss in the death of Rai Sahib Maya Das Puri, which occurred on March 3rd after a very short attack of pneumonia.

No. 22 Party has now completed its programme of Riverain Surveys, and will be diverted next season to special and rectangulation surveys for the Bhakra Dam Irrigation Project.

44. Training.—It has been decided that not more than six soldier surveyors should join the Frontier Circle from Roorkee each year.

45. Special.—The survey units on the frontier continued to co-operate closely with military formations at special training exercises and at manœuvres (p. 3).

Dr. de Graaff Hunter, Director Geodetic Branch, visited Murreë in May, and several improvements in methods and computations for rapid triangulation were discussed with the Officer Commanding "A" Company and the Officer in Charge No. 18 Party.

Major Norman has written a professional paper entitled "Notes on Air Survey in India", which should be of great value to officers of the Department.

46. The field work of units was as follows:—

"A" Survey Company. Topography on scales of $1\frac{1}{2}$ -inches and 4-inches=1 mile and 1:13,333, in sheets 43 B, F, and G/2.

"E" Survey Company. Topography on $\frac{3}{4}$ -inch = 1 mile scale in sheet 35 I; on 1-inch = 1 mile scale in sheets 34 K and O. Triangulation in advance in sheets 34 K, 35 I and 40 N and O.

No. 18 (Air Survey) Party. Compilations completed of 4-inch forest surveys of Chittagong District, and compilations of air surveys of tribal area of North-West Frontier Province continued.

No. 22 (Riverain) Party. Work for Punjab Government, including completion of demarcation of boundary between Punjab and United Provinces in Gurgaon District. Riverain surveys along Jumna river. Rectangulation, levelling and special irrigation surveys in sheets 44 B and F, and forest survey in Chānga Mānga Reserve Forest.

No. 23 Party. Rectangulation and levelling and special 4-inch irrigation surveys for the Punjab Government, completion of Haveli Project in 39/O, and commencement of Muzaffargarh Project in sheets 39 J and K and Abbāsia Project in 39 L.

Settlement Survey Detachment. Cadastral surveys in Dera Ismail Khān District along the Indus river sheets 38 and 39.

"A" Survey Company

Officer commanding.—Major C. G. Lewis, O.B.E., R.E.

47. General.—The recess headquarters of the Company are at Murree, and the field headquarters at Rāwalpindi.

The survey of Chitrāl in the N. W. F. Province was completed, and that of the Kāgān valley of Hazāra district was commenced. As in the previous year, field work was carried out during the summer as well as in the cold weather, most of the country under survey being snow-bound during the winter.

During February Lt. I. H. R. Wilson, R.E., carried out an experimental stereo photographic survey in Almora district United Provinces, with a *Wild* photo-theodolite, with a view to ascertaining the suitability of this method for the cadastral survey of the cultivated areas of the district.

48. Personnel.—The average strength during the year was 2 class I, 3 class II, 7 Upper Subordinate and 34 Lower Subordinate officers, with 3 soldier surveyors under training.

The following officers were transferred from the company; Lieuts. Cadell and Wilson, during the field season, Mr. Muhammad Husain Khan, K.S. (U. S. S.) before the field season, and Mr. Nanak Chand Puri, R.S. (Class II) at close of the field season. Mr. Afraz Gul Khan, K.S., C.H. (Class II) joined Mr. P. C. Visser's expedition to the Karakoram in April 1929.

Mr. A. A. Graham (Class II) and Mr. Sajawal Khan (U. S. S.) joined the company at beginning of the field season, and Mr. P. A. Thomas (Class II) and Mr. Muhammad Akbar (U. S. S.) joined in March and April 1929 respectively for work in Chitrāl.

49. Field work.—Mr. C. M. Aslam (Class II) with Mr. Sajawal Khan (U. S. S.) and 12 surveyors, nine of whom were under training, surveyed 655 square miles on the scale of $1\frac{1}{2}$ inches = 1 mile in Hazāra District and in tribal territory, N.W.F.P. (sheets 43 B and F). This area was steep and hilly and in some parts covered with thick forest. The areas surveyed included the eastern slopes of the Black Mountain and Nandihar tribal territory, where surveyors were only admitted after protracted negotiations with the tribal headmen. Great credit is due to Mr. C. M. Aslam and Mr. Sajawal Khan for their tact and persistence in face of the general unfriendliness and suspicion of the tribesmen, which continued till the work was completed at the end of July 1929.

Mr. Sajawal Khan (U. S. S.) with 5 surveyors under training, surveyed 23 sq. miles in November and December 1928 on the scale of 1:13,333, in the Rāwalpindi district of the Punjab (sheet 43 G/2), as an extension to the Rāwalpindi Guide Map, for publication on the scale of 3-inches = 1 mile. Mr. Lalān Khan, C.H., I.D.S.M. (U. S. S.) with



TIRICH MIR FROM THE SOUTH EAST.

Photo. preserved & printed at the Offices of the Survey of India, Calcutta, 1920.

Mr. Quadir Dad (U. S. S.) and one surveyor, surveyed 27 sq. miles on the scale of 4-inches = 1 mile in the Murree Hills, (sheet 43 F/8), completing the survey for the Murree Hills guide map, scale 3-inches = 1 mile.

Surveys and triangulation carried out in the Dir Swāt and Chitral agency and in Waziristān, N.W.F.P. are reported in the supplement to this general report.

50. Areas surveyed.—Areas surveyed include, 655 square miles of original survey on the scale of $1\frac{1}{2}$ -inches = 1 mile in Hazāra district and tribal territory, N.W.F.P.

23 square miles of re-survey on the scale of 1:13,333, near Rāwalpindi, Punjab.

27 square miles of re-survey on the scale of 4-inches = 1 mile in the Murree Hills, Punjab and N.W.F.P.

51. Recess duties.—Fair mapping was carried on throughout the year, both at field and recess headquarters, and was organized in two sections with a nucleus of 5 draftsmen permanently employed at headquarters. During the cold weather Lt. D. McK. Burn, R.E. (Class I) and Mr. N. C. Puri, R.S. (Class II) were in charge of the two drawing sections, assisted by Messrs. D. R. Vohra, Laltan Khan and Chiragh Shah (U. S. S.). During the hot weather the drawing sections were in the charge of Mr. A. A. Graham (Class II) and Mr. C. M. Aslam (Class II) with Messrs. D. R. Vohra and Sajawal Khan (U. S. S.) as assistants.

In addition to current $1\frac{1}{2}$ -inch mapping, the Rāwalpindi Guide Maps were submitted during the year, for publication on the scale of 3-inches = 1 mile.

Computation of current triangulation and the adjustment of old triangulation was carried out throughout the year by Mr. D. M. Das (U. S. S.) assisted by four computers.

"E" Survey Company

Officer commanding.—Major E. O. Wheeler, M.C., R.E.

52. General.—The field and recess headquarters were at Quetta (Baluchistān).

Owing to climatic conditions in the area under survey and to the necessity of nearly all movement being by road, approximately half the company took the field at a time, the other half continuing fair mapping at headquarters. Surveys were extended southward on the Baluchistān plateau, astride the new road from Quetta to Karāchi. The modern survey of sheets 34 K and O is now completed, and that of 35 I commenced. 9,253 sq. miles were triangulated in advance for subsequent seasons.

53. Average strength during the field season was 2 Class I, 5 Class II (1 on probation), 3 Upper Subordinate (2 on probation), and 40 Lower Subordinate officers. There is also a Reproduction Section with a strength of about 13 men.

Personnel.—Lt. I. H. R. Wilson, R.E., joined the company in April 1929. Mr. A. M. Talati (Class II) was transferred from the company in December 1928, and his place was taken by Mr. Moquimuddin Ansari (Class II). 6 soldier surveyors joined the unit for instruction, of whom 2 were reverted to their regiments. 2 Upper Subordinate officers, Mr.

Muhammad Hussain Khan and Mr. Iltifat Husain, and 6 surveyors were transferred to the company during the year, while one Class II officer, 8 Upper Subordinates and 8 surveyors and soldier surveyors were transferred to other units.

54. Field work was organized as follows :—

Winter—

Camp (1).—Mr. A. J. A. Drake, D.C.M. (Class II) assisted by 1st class surveyor Asghar Ali, with 3 surveyors, 1 pupil and 5 soldier surveyors, surveyed 520 square miles on the 1-inch = 1 mile scale in sheet 34 K.

Camp (2).—Mr. Khushal Khan (U. S. S.) with 6 soldier surveyors, surveyed 1,054 square miles on the $\frac{3}{4}$ -inch = 1 mile scale in sheet 35 L.

Inter-class surveyor Nur Ahmad, assisted for part of the season by 2 soldier surveyors, surveyed 260 square miles on the 1-inch = 1 mile scale in sheet 34 O.

Instructional camp.—Mr. Drake assisted by 1st class surveyor Asghar Ali, also gave six weeks instruction to one pupil surveyor and 5 soldiers before the latter were sent to their regular work in sheet 34 K.

Summer—

Camp (3).—Mr. M. Ansari, B.A., (Class II) assisted by Mr. J. C. Berry, (Class II) and 1st class surveyor Thakur Singh, C.H., with one class I officer, one Upper Subordinate officer and 16 surveyors and soldier surveyors, surveyed 1,560 square miles on the 1-inch = 1 mile scale in sheet 34 K.

Triangulation and traversing.—Messrs. Hurley and Ganapathy (Class II) and 1st class surveyor Muhammad Akbar (now U. S. S.) triangulated 7,899 square miles in sheets 40 N and O for survey in subsequent seasons on the $\frac{1}{2}$ -inch = 1 mile scale. Mr. Khushal Khan (U. S. S.) in addition to being in charge of camp (2), triangulated 1,054 square miles in sheet 35 I for survey on the $\frac{3}{4}$ -inch = 1 mile scale, and Mr. Abdul Rashid Khan (U. S. S.) reconnoitred 1,045 square miles in sheet 34 L for survey on the 1-inch = 1 mile scale. The latter officer was only able to observe 520 miles of this triangulation during the year under report, owing to haze.

55. Areas surveyed.—Original survey of 2,340 square miles on the 1-inch = 1 mile scale, and of 1,054 square miles on the $\frac{3}{4}$ -inch = 1 mile scale; a total area of 3,394 square miles on both scales. All this work lay in Kalāt state and Chāgai district, in Baluchistān. The triangulation lay in Kalāt state, and in Jodhpur and Jaisalmer states of the Rājputāna Agency (sheets 40 N & O).

56. Recess duties.—Fair drawing was carried out throughout the year, owing to only half the company taking the field at a time, *vide* para. 52 above. Drawing sections were under the charge of Messrs. Talati, Drake and Ansari (Class II), assisted by Messrs. J. C. Berry and C. T. Hurley (Class II) and Messrs. Muhammad Husain Khan and Khushal Khan (U. S. S.). The Computing section was under the charge of Mr. M. M. Ganapathy, B.A., (Class II).

Owing to the field season having continued until the middle of June, 1929, the mapping of all field work was not completed by the end of the survey year 1928-29. It will however be completed before the end of March 1930.

57. Special drawing and reproduction section.—This section, first under the orders of vandyke operator Attar Singh and later of

Mr. Sadiq Ali (Assistant 2nd Division P. L. O.), worked full time throughout the year, almost entirely on payment jobs. These jobs included the reproduction of a large number of *musāvis* for No. 24 (Lloyd Barrage Rectangulation) Party, as well as numerous jobs for the military authorities in Quetta.

58. Military training.—At the end of June, Major Norman of No. 18 (Air Survey) Party brought Mr. Mohd. Hasan, K.S., and two surveyors to Quetta, to instruct "E" Company in air survey work, and in rapid methods of triangulation. Major Norman remained in Quetta till the first week of August, and the others until after Western Command manœuvres (October 1929).

All officers were trained in the use of the *Wild* theodolite, and Hunter short base, and numerous schemes were carried out in rapid triangulation, several being combined exercises with the Royal Artillery.

At the same time, "E" Company personnel were trained in the latest methods of air survey, and a map of the Western Command manœuvre area 1929, was produced from air photographs taken by the R. A. F.

For photography, both the P/7, 5" by 4" plate camera, and the F/8, 7" by 7" film camera, were used. The immense superiority of the latter was very apparent, both as regards ease of operation in the air, and quickness of compilation of the map, the latter due to the very much larger area covered by each photo. The films used however had without exception perished, and pictures were of very poor quality. Steps are being taken to remedy this.

In compilation, the radial line method was used, principal points being transferred stereoscopically. Approximate contours were applied after ascertaining relative heights of various points by measuring their relative parallax under the grid of the Barr and Stroud stereoscope.

Considerable progress was made, both in methods of photography and of compilation. A full report on work done will be found in appendix to technical supplement of "E" Company for 1929.

The company will also co-operate in the Western Command Signal exercise and manœuvres in October 1929.

No. 18 (Air Survey) Party

Officer in charge.—Major W. J. Norman, M.C., R.E.

59. General.—The primary duty of the party is to train survey personnel in the compilation of small-scale topographical maps from air photographs, and to maintain close co-operation with the Royal Air Force who do the photography.

The party headquarters are at Murree with "A" Survey Company, and field headquarters at Peshāwar where H. Q. No. 1 (Indian) Group R. A. F. is located.

Efforts have been made to simplify and standardize the procedure of air survey, using the methods laid down in professional paper No. 3 of the War Office Air Survey Committee.

During the year Major Norman has written a pamphlet, entitled "Notes on Air Survey in India", which is intended to give officers of the Survey of India a general idea of the theory and practice of air survey. This will be published as a professional paper.

A detachment of the party was attached to "E" Survey Company during the summer.

60. Personnel.—Mr. P. A. Thomas (Class II) was under training in the party for 6 months and was transferred to "A" Survey Company in April.

The average number of surveyors with the party was about 8; mostly under training in air survey.

Mr. Ghulam Hasan (U. S. S.) and K. S. Muhammad Hasan (U. S. S. now Class II) have been with the party during the whole year.

Mr. N. C. Naug (U. S. S. Probationer) has also been under training. There is also a reproduction section with a strength of about 6 men.

61. Areas surveyed.—During the survey year October 1928 to September 1929 the Royal Air Force supplied air photographs covering 10 square miles in Peshāwar district. No. 18 Party turned out compilation of 1,544 square miles on the 4-inches = 1 mile scale for Chittagong Forest Surveys in Bengal.

62. Chittagong forest surveys.—This work was received in May 1927 but little progress was made till early in 1928. After which date, by employing practically the whole strength of the party on these compilations, they were completed in January 1929 and delivered to the Settlement Officer, Chittagong.

The methods used have already been referred to in the two previous general reports. A full and detailed report is included in the technical supplement to this report.

63. Original survey of tribal territory.—This has been carried out to provide maps of country inaccessible to the ground surveyor. There is at present no known method of providing an accurate map under the conditions prevailing.

The maps now produced from air survey give a good representation of the country, though it is often considerably distorted.

64. Revision survey.—This has been undertaken to provide the R. A. F. with photographic training, and at the same time to bring up-to-date maps which are over 20 years old.

65. Photographic training of R. A. F.—All vertical photographs taken by the R. A. F. at Kohāt, Peshāwar and Risālpur for training purposes have been sent to No. 18 Party for criticism. These photos have been examined for—

- (a) Correct course
- (b) Constant height
- (c) Tilt (i) Fore and aft
(ii) Lateral
- (d) Exposure interval

and the criticisms have been communicated to the pilots.

66. Work with "E" Survey Company.—A detachment under K. S. Muhammad Hasan (Class II) was attached to "E" Survey Company during recess and the personnel of "E" Survey Company was trained in air survey. A combined exercise was undertaken with the R. A. F. and the resulting map was used on Western Command manoeuvres.

Major Norman also spent six weeks with "E" Company at Quetta during this period.

67. Film camera.—The new F (8) automatic film camera has been used during the year and has proved satisfactory.

It has been found that films deteriorate very rapidly in the hot climate and special arrangements are being made to bring out and to store the films in cold storage plant.

68. Reproduction section.—A large amount of work for the reproduction section has been received from H. Q. Northern Command and other military formations. This has enabled the section to keep two hand presses employed.

The section attended Northern Command manœuvres in November and printed off "situation maps" each night for issue the following morning.

No. 22 (Riverain) Party

Officer in charge.—{ Mr. Dhani Ram Verma, R.S., upto 21-12-28.
,, A. M. Talati, L.C.E., from 22-12-28.

69. General.—This party continued working on special surveys for Punjab Government Departments who pay for the work. The programme for the year included:—

- (i). Traversing the riverain area along the Jumna river, and laying down base-lines in sheets 53 C, F, G, H and 54 E and plotting and compiling settlement *musāvis* required for cadastral surveys by the Settlement Department.
- (ii). Demarcation of a part of the boundary between the Punjab and the United Provinces in sheet 53 H. This is to be a fixed permanent boundary in place of the changing main channel of the Jumna river.
- (iii). Inspecting and refixing missing stones of base-lines on the Jhelum river in Jhelum district fixed in 1912-13-14 and 1925-26 in sheets 43 D, G and H for the Punjab Government.
- (iv). Rectangulation, levelling and 4-inch survey of a strip falling between the Sutlej Valley and the Upper and Lower Bāri Doāb canal projects in sheets 39 N, 44 B, E, F and I for the Irrigation Department.
- (v). Survey of Chānga Mānga Reserved Forest on scale 4-inches = 1 mile, with one foot contouring in Lahore district, sheets 44 E and I for the Conservator of Forests, Western Circle.

The headquarters of the party remained at Lahore till the 8th May 1929 and then moved to Solon (Simla Hills).

This season's work has brought to a close the programme of Riverain surveys which was first commenced by No. 18 Party in 1908. An account of this survey is now under preparation.

70. Personnel.—The average field strength of the party was one class II officer, 3 Upper Subordinate officers and 59 Lower Subordinates.

During the year Mr. Bakhshi Harnam-Singh (U. S. S.) was transferred from the party, 4 surveyors and 3 traversers were transferred to

other parties and 16 purely temporary traversers, draftsmen, levellers and computers were discharged.

71. Field work was organized as follows:—

Camp (1).—Mr. Muhammad Najamuddin, B.A., (Class II) with 8 surveyors, 10 traversers, and 2 levellers carried out surveys (a), (b), (d) and (e) below.

Preparation of spot-level charts and contour sheets was carried out during the field season and 17 sheets were sent for publication at Dehra Dūn by close of field season.

Camp (2).—Mr. Bakhshi Harnām Singh (U. S. S.) till 31-1-29, and Mr. Lalbir Singh (U. S. S.) from 1-2-29, with 9 traversers carried out surveys (c) below. 92 Base-lines on right bank of Jhelum river in Jhelum district were inspected for the local authorities. 69 stones were found uprooted by villagers or destroyed by erosion of the river, out of 274 stones laid in 1912—14, while all stones laid in 1925-26 were found. The missing stones were refixed except for three base-lines where the river cuts through hills.

72. Areas surveyed.—(a) 524.4 square miles of original survey were completed on scale 4-inches = 1 mile, in Multān, Montgomery and Lahore districts in sheets 39 N, 44 B, E, F and I (extending the northern limit of the Sutlej Valley Canals area to meet the Upper and Lower Bāri Doāb Canals areas).

(b) 20.0 square miles of original survey were completed on scale 4-inches = 1 mile, for the Chānga Mānga Reserved Forest Survey in Lahore district in sheets 44 E and I.

(c) 897 square miles of main and minor traverses along the Jumna river in Karnāl, Rohtak, Gurgaon, Sahāranpur, Muzaffarnagar, Meerut, Bulandshahr and Aligarh districts for fixing base-lines for future settlement surveys.

(d) 111.3 square miles of the Sutlej Valley Survey were rectangulated into 25-acre rectangles previous to being surveyed.

(e) 149 square miles of tertiary levelling was carried out in areas (a) and (b) to form basis for one foot contouring.

73. Computing and plotting Section.—Mr. Badlu Ram (U. S. S.) with 14 computers and 6 draftsmen at field headquarters computed the traversing *pari passu* with the field work, and prepared plots on 4-inch = 1 mile scale of all traverse stations and base-lines; riverain *mauza* boundaries were reduced from existing large-scale settlement *musāvis* and transferred to these plots.

74. Recess duties.—Mr. Muhammad Najamuddin with 14 Lower Subordinates, assisted by Mr. Lalbir Singh, carried out all fair mapping necessary.

Mr. Badlu Ram with 13 Lower Subordinates completed all traverse computations and prepared manuscript traverse charts for degree sheets.

All fair-drawn sheets were sent to Dehra Dūn for publication, and 60 published sheets of Sutlej valley survey, one sheet of Chānga Mānga survey, and 4 sheets of Punjab-U. P. boundary survey were delivered to the officials concerned.

All professional records of the riverain survey were properly completed, and sent to Frontier Circle Office for safe custody.

No. 23 (Rectangulation) Party

Officer in charge.—Mr. H. B. Simons.

75. General.—The party was employed by the Punjab Government on completing the survey programme of the Haveli Irrigation Project, and commenced the survey and rectangulation of a new area for the Muzaffargarh District Indus Canals. In addition, a small extension to the Sutlej valley project in the Bahāwalpur state known as the Abbāsia Canal was rectangulated and levelled to 25 acres after the usual traversing had been completed. Early in September 1928 two camps were sent out to the field for the purpose of starting the traverse of the Muzaffargarh District Indus Canal area and to subdivide to 25 acres a small area of the Haveli project previously rectangulated to 100 acres.

The party headquarters moved from Solon to Multān on the 8th October 1928 and returned to recess on 26th April 1929.

76. Personnel.—A considerable addition was made to the personnel of the party. The field strength comprised one Class I Officer, 3 Class II Officers, 4 Upper Subordinate Officers and 108 Lower Subordinates and were distributed as follows:—

Mr. F. W. Smith (Class II) assisted by Mr. Syed Imamat Husain Naqvi, U. S. S., Probationer with 30 traversers and 8 computers completed (i) the traversing and embedding of the corner stones of the main 2,400-acre rectangles of the whole area covered by the Muzaffargarh District Indus Canal Surveys, (ii) the subdividing to 25 acres of all exterior lines from the extreme south of the area to roughly $30^{\circ} 15'$; north of this it was only possible to embed, in addition to the corner stones of the main 2,400-acre blocks, the first 100-acre stone to the east, and (iii) the subdivision of interior lines to 25 acres.

Mr. Jiya Lal Sahgal (Class II) with Syed Nayar Husain computer as assistant and 27 levellers completed (i) the levelling over 25-acre pegs the remaining area south of $30^{\circ} 25'$ of the Haveli Project east of the River Chenāb, (ii) rectangulation to 25 acres and levelling of a portion to the extreme south of the new Muzaffargarh District Indus Canal area.

Mr. Duni Chand Puri (Class II) assisted by Mr. Sheikh Allaudin, (U. S. S. Probationer) with 27 surveyors and rectangulators (i) subdivided to 25 acres all crown waste-lands with stones and with pegs the remaining area of the Haveli Project south of $32^{\circ} 25'$ and east of the River Chenāb, (ii) reduced all village boundaries from village *musāvis* falling in the new Muzaffargarh District Indus Canal Area, (iii) subdivided to 25 acres a portion of the new area.

Mr. Muhammad Husain Khan k.s. (U. S. S.) with 7 traversers, levellers and rectangulators and 2 computers traversed, rectangulated and levelled the whole of the extension of the Sutlej Valley Project known as the Abbāsia Canal Area in the Bahāwalpur State.

Mr. Abdul Ghani Qureshi (U. S. S.) with 4 surveyors completed the 4-inch survey in connection with the Haveli Project.

Two draftsmen were occupied at field headquarters in completing the 4-inch planetables adjoining the Sind-Sāgar Area from the 6-inch surveys done by the Irrigation Department.

77. Areas surveyed.—The areas for various projects are as follows :—

Haveli Project—

Rectangulated and levelled to 25 acres	1,400 square miles.
Original 4-inch = 1 mile survey	172 " "
Revision 4-inch = 1 mile survey	63 " "

Muzaffargarh District Indus Canal Area—

Traversed	1,308 linear miles.
Exterior stones embedded	1,650 square "
Rectangulated to 25 acres	900 " "
Levelled to 25 acres	180 " "

Abbāsia Canal Area—

Traversed	81 linear miles.
Rectangulated to 25 acres and levelled	155 square "

The totals for the three projects are—

Traversing	1,389 linear miles.
Rectangulation to 25 acres	2,445 square "
Planetabing 4-inch = 1 mile	235 " "
Levelling to 25 acres	1,735 " "

The country dealt with, comprises cultivated plains watered by inundation canals, and desert country with scrub jungle; a thickly wooded area occurs at the junction of the Indus and Panjnad and along the Indus river, necessitating very heavy line-clearing. This delayed the work considerably and prevented the completion of the original programme.

78. Traversing.—The traverse covered the whole Muzaffargarh District Indus Canal Area and was controlled by connections to the Great Indus series and stones of the old Sind-Sāgar Rectangulation, the connection with the latter being exceedingly good.

79. Rectangulation.—The position of the corners of the main 2,400-acre rectangles of the Muzaffargarh District Indus Canal Area was computed, as in the past, from the nearest traverse stations and marked by stones. In the northern portion of the new work where the stones of the exterior lines could not all be embedded, the first 100-acre stone to the east was also fixed by the traversers to enable the alignment to be carried out next field seasons without the usual bearing and distance. These 2,400-acre rectangles will be further subdivided to 25-acre blocks.

The Haveli area which had previously been subdivided to 100 acres was now further subdivided to 25 acres, the corners of the 25 acres being marked by stones in the crown waste-lands and by pegs over the remaining area.

80. Special 4-inch surveys.—The five sheets remaining in 39 N/8, O/1 and 5 were completed. In addition 6 sheets were revised and 7 surveyed for the first time in 39 O/2 and 3.

81. Levelling.—Tertiary levelling was carried out over the whole of the remaining area of the Haveli Project rectangulated to 25 acres south of 32° 25', and over a portion in the extreme south of the Muzaffargarh District Indus Canal Project.

82. Recess duties.—Mr. Jiya Lal Sahgal (Class II) with 11 computers and levellers were employed in computing the heights and preparing spot-height charts of the whole area levelled. Mr. D. C. Puri (Class II) with 9 draftsmen and surveyors completed the planetables of the whole Haveli Project, while the officer in charge, assisted by Mr. Abdul Ghani Qureshi (U. S. S.) and 14 surveyors, completed and fair drew the contour charts.

All the sheets of the Haveli Project were sent to press.

Settlement Survey Detachment

Officer in charge.—Rai Sahib Maya Das Puri.

83. General.—The detachment continued traversing for settlement purposes along 74 miles of the Indus river in the Dera Ismail Khān district in degree sheets 38 P, 39 I, 38 L, and 39 M; field headquarters were at Campbellpore. On the 6th November orders were received from the North-West Frontier Government that the settlement of Dera Ismail Khān district had been postponed for five years and that no survey was now required. By that time field work in nearly 68 riverain villages had almost been completed, while in four *pukka* hilly villages it had been partly done. At the request of the Deputy Commissioner, Dera Ismail Khān, these 68 riverain villages were completed, while the four hilly villages were left uncompleted.

84. Personnel.—The field strength of the detachment was 2 Upper Subordinate Officers, and 39 Lower Subordinates distributed as follows:—

- (1). Mr. Daulat Ram Vohra, (U. S. S.) held charge of camp No. 1 with 11 traversers.
- (2). Mr. Dalip Singh Gandhi (U. S. S.) held charge of camp No. 2 with 10 traversers.
- (3). Babu Joti Sarup first class computer held charge of the computation section with nine computers.
- (4). Babu Ram Das first class computer in addition to his duties as storekeeper held charge of the plotting section with 5 draftsmen till the middle of December, after which first class traverser Lorind Chand supervised the plotting and compilation of boundaries.

Men withdrawn from field during November 1928 assisted generally in computations and plotting at field headquarters Campbellpore. They were, however, gradually transferred to other units during November, December, and January excepting 11 purely temporary hands who were discharged; and the detachment closed its work on the 4th February 1929.

85. Areas surveyed.—200 square miles in 68 villages were traversed and completed; while four hilly villages covering an area of 123 square miles, in which work had been partly done, were left incomplete.

86. Traversing.—The riverain work was connected to 87 base-lines laid out some years ago by No. 22 Party and to 4 G.T. stations. 4,398 stations were laid out in 68 villages and 1,218 linear miles of traverse run through 200 square miles.

87. *Plotting and compilation of riverain boundaries.*—Plotted and boundary compiled *musāvis* (settlement mapping sheets) in the *kacha* area (area under water action) on the scale 24-inches = 1 mile, were prepared and supplied to the Deputy Commissioner, Dera Ismail Khān for the detail survey. Besides these all the work done during the year was plotted on the riverain sheets on the scale 4-inches = 1 mile, and their traces supplied.

88. *Computations.*—The co-ordinates of all the points laid out during the season in 68 riverain villages, were computed.

VI.—SURVEY REPORTS, CENTRAL CIRCLE

DIRECTOR:— $\left\{ \begin{array}{l} \text{Lt.-Col. L. C. Thuillier, I.A., to 13-10-28.} \\ \text{,, ,, R. Foster, I.A., from 14-10-28 to 31-10-28.} \\ \text{,, ,, S. W. Sackville Hamilton, D.S.O., R.E., from 1-11-28.} \end{array} \right.$

89. Summary.—The units administered by the Central Circle were Nos. 1, 5, and 24 Parties, Benares and Bhopāl Survey Detachments, Air Survey Traverse Detachment, and No. 3 Drawing Office.

The Rājputāna Detachment was renamed the Benares Detachment with effect from 1st October 1928.

The Officer in charge, No. 5 Party, in addition to his normal duties, continued to act as Assistant Director of Surveys, Central Provinces and administered the Revenue, Town, and other surveys of that Province.

A detachment was formed under the executive charge of Mr. Ram Narayan Hastir, (U. S. S.), during November 1928, to execute traversing for control of air surveys in the districts of Sitāpur, Bahraich and Fyzābād, and the work is in progress. Correspondence and accounts for the detachment were done by the Circle Office.

90. Training.—Two Class II Officers completed training in Nos. 1 and 5 Parties and were confirmed in their appointments with effect from 16th November 1928, and two probationers were transferred from the Geodetic Branch in October 1928. A probationer in the Upper Sub-ordinate Service was also transferred from the Frontier Circle in May 1929. Eleven pupil surveyors, 2 pupil draftsmen, and two pupil computers commenced their training in field and recess work in Nos. 1 and 5 Parties, Benares Detachment, and No. 3 Drawing Office. Two of the pupil surveyors were discharged as unlikely to become efficient, and two soldier surveyors have been retained in the Survey of India to undergo a second period of extra training.

91. The field work of parties and detachments was as follows:—

No. 1 Party.—Topography on 1-inch = 1 mile scale in sheets 64 M and 72 D. Triangulation in advance.

No. 5 Party.—Topography on 1-inch = 1 mile scale in sheets 64 B and 64 C. Triangulation in advance.

No. 24 Party.—Traversing and demarcation of rectangles for the Bombay Government in the area commanded by the Lloyd Barrage Project in Sind.

Benares Detachment.—Special city-surveys in Benares on the 16- and 64-inches = 1 mile scales in sheets 63 K and O and a special survey on the 16-inches = 1 mile scale in sheet 45 B in Jodhpur State.

Bhopāl Detachment.—Settlement surveys on the 16-inches = 1 mile scale in Bhopāl State. Triangulation for Forest Surveys in advance.

Air Survey Traverse Detachment.—Traversing for control of air surveys on 16-inches = 1 mile scale in Sitāpur and Bahraich Districts.

No. 1 Party

Officer in charge.—

{	Lt.-Colonel R. Foster, I.A., to 22-3-29.
	Mr. J. C. O. Lears, from 23-3-29 to 8-5-29.
	Captain G. H. Osmaston, M.C., B.E., from 9-5-1929.

92. General.—The party continued surveys on the 1-inch = 1 mile scale in Bihār and Orissa and the Central Provinces, in sheets 64 M and 72 D. The field head-quarters of the party were at Daltonganj.

Personnel.—The field strength of the party, excluding the Officer in charge, was 3 Class II officers, 1 Class II probationer, 13 surveyors, 2 computers and 5 pupil surveyors under training.

93. Areas surveyed.—2,279 square miles of 1-inch re-survey in sheets 64 M and 72 D in Gayā, Palāmau, Shāhābād and Hazāribāgh districts, and in Surgujā State were completed. This area includes 3 square miles of protected forests in the Palāmau district.

1,362 square miles were triangulated in sheet 64 M in the Mirzāpur district and in Surgujā State; a triangulated area of 273 square miles in sheet 64 M/10 was surveyed.

94. Field work was organized as follows:—

Camp (1). Mr. F. B. Kitchen (Class II), Mr. D. N. Vasudeva, B.A. (Class II probationer), and 6 surveyors (increased to 7 in December), surveyed 1,355 square miles on the 1-inch = 1 mile scale in sheets 72 D/2, 3, 4, 6, and 7 in Gayā, Palāmau, Shāhābād and Hazāribāgh districts. The training of 5 pupil surveyors was undertaken by this camp.

A part of the area, usually inundated from October to January, consisted of heavily cultivated flat country with innumerable *bunds*; the remainder, of heavily-wooded low hills interspersed with cultivation.

Camp (2). Mr. H. T. Hughes (Class II), with 7 surveyors, (reduced to 6 in December), surveyed 924 square miles on the 1-inch = 1 mile scale in sheets 64 M/9, 10 and parts of 64 M/13 and 14 in Palāmau district and in the Surgujā State.

The greater part of the area comprised densely wooded low hills and undulating plains interrupted by villages with their indispensable patches of cultivation. The higher hills on the south-east, with densely wooded slopes, rose to an elevation of 3,700 feet.

Malaria was prevalent in this area and added to the difficulty of survey. Nearly every surveyor of this camp was at one time or another laid up with it. The forests were infested with wild animals, including tiger, bear, leopard, bison and various kinds of deer.

Camp (3). Mr. M. N. A. Hashmie, B.A. (Class II), with one computer as recorder, triangulated 1,362 square miles in sheets 64 M/1, 2, 5, 6 and 10 in Mirzāpur district and Surgujā State.

Thickly-forested high hills, with occasional flat tops locally known as *pats*, covered the area. Villages were scarce, and means of communication difficult, paths often having to be cleared for marching.

95. Recess duties.—Fair mapping was divided into two sections under Messrs. F. B. Kitchen and H. T. Hughes. The mapping of all field work with which was incorporated reductions to 1½-inch, from 2-inch sheets 64 M/13 S and 64 M/14 N and S, was completed during the year.

Mr. M. N. A. Hashmie, aided by one computer, completed the computations of the triangulation.

No. 5 Party*Officer in charge.—Major L. H. Jackson, I.A.*

96. General.—This party continued surveys on the 1-inch=1 mile scale in the Central Provinces in sheets 64 B and 64 C. The field headquarters were again at Nagpur in order to keep in touch with the Settlement Commissioner, Central Provinces, the Officer in Charge of the part being also Assistant Director of Surveys, Central Provinces.

Personnel.—The field strength, apart from the O.C., was 2 Class I (one on probation), 3 U.S.S. officers, 21 surveyors and 3 computers.

97. Areas surveyed.—3,028 square miles of 1-inch survey (2,14 square miles original and the remainder supplementary) in sheets 64 J and 64 C, 4,847 square miles of triangulation in sheets 64 F and 64 J, and 48.9 linear miles of traversing in sheet 64 J. The triangulation was connected with the Jubbulpore Meridional and Bilāspur Meridional Series and the traverse with the triangulation carried out by the party.

98. Field work was organized as follows:—

Camp (1).—Head-quarters Baihar and later Bichhiā.—Mr. Shadi Lal Dube, assisted by surveyor Hakdad Khan, with 21 surveyors (including a Class II officer and 2 surveyors under training), completed 2,142 square miles of original and 886 square miles of supplementary survey in the Bālāghāt, Drug and Mandlā districts, and in the C. P. Feudatory States. The country was, for the most part, sparsely inhabited and lacking in communications and consisted chiefly of heavily wooded hills necessitating much plane-table traversing. A small portion of the area falling in Mandlā district was open and undulating with very fair communications. Up to the end of January, the work was much delayed by the prevalence of malaria, and during March and April by lack of water.

Camp (2).—Mr. N. D. Joshi triangulated 1,928 square miles and traversed 26.8 linear miles in sheet 64 J in Bilāspur district and in the C. P. Feudatory States. The country consisted chiefly of undulating plains with detached hill-ranges, except in the north-east corner, which is very hilly. About half the area is densely wooded and communication are fair.

Camp (3).—Mr. J. R. Chibbar triangulated 1,821 square miles and traversed 22.1 linear miles in sheet 64 J in Bilāspur district and in the C. P. Feudatory States. The country is hilly, densely wooded, and contains very few villages. Communications are bad.

Camp (4).—Mr. M. D. Nangia, B.A., triangulated 1,098 square miles in sheet 64 F in Mandlā district and in Rewah State. About half the area consists of heavily wooded flat-topped hills, the remainder of open and undulating plains interspersed with tree-clad hill-ranges. Except in the hills, communications are fairly good.

99. Recess duties.—Fair mapping was divided into two sections under Messrs J. H. Johnson and Shadi Lal Dube. The mapping of all field work was completed during the year. Messrs. N. D. Joshi, J. R. Chibbar, and M. D. Nangia were responsible for the computation of their triangulation and traversing.

No. 24 Party (Sind Rectangulation)*Officer in charge.*—Lieut.-Col. A. H. Gwyn, I.A.

100. General.—The work consists of laying out 320-acre and 64-acre rectangles in the British and Khairpur State areas respectively. Field head-quarters opened at Hyderābād (Sind) on 25th October 1928, and closed on 27th April 1929; the office then moved to Karāchi for recess.

Personnel.—The field strength, apart from the O.C., was 3 class II officers, and 1 U. S. S. officer, with 16 traversers, 30 rectangulators, and 6 levellers.

101. Areas surveyed—4,088 square miles of traversing and demarcation of corners of main rectangles (of 4 square miles) for subdivision in 1929-30 to 320 and 64 acres, completing the traversing programme of the party; 3,244 square miles of 320-acre rectangles; and 5,100 square miles of tertiary levelling.

Bonus system of payment.—The experimental plan of giving traversers and rectangulators and their squads extra pay for increased out-turn was found to be only partially successful this year.

102. Field work was organized as follows:—

Camp (1).—Mr. O. N. Pushong (Class II), with 10 traversers, carried out the traverse and corner-laying operations in the British area, 2,800 square miles.

Camp (1-A).—Mr. T. M. C. Alexander (Class II), with 6 traversers, carried out similar operations in the Khairpur State, 1,288 square miles.

Camp (2).—Mr. S. R. Gupta, B.A. (Class II), with 15 rectangulators, subdivided 1,616 square miles into 320-acre rectangles.

Camp (3).—Mr. Amrit Ram (U.S.S.), with 15 rectangulators, subdivided 1,628 square miles into 320-acre rectangles.

No. 6 Levelling Detachment.—Mr. Abdul Karim, B.A. (Class II) levelled 196 linear miles of tie-lines.

Nos. 7, 8 and 9 Levelling Detachments under Lower Subordinate officers levelled a network of lines covering 5,100 square miles.

103. Recess duties.—Mr. O. N. Pushong with 2 men completed the traverse computations for the past field season; Mr. S. R. Gupta prepared *musavi* originals for reproduction for the Chief Engineer, Lloyd Barrage and Canals Construction; and Mr. Abdul Karim completed the levelling computations. The miscellaneous index mapping was directly under the Officer in charge.

Benares Detachment

Officers in charge.— $\left\{ \begin{array}{l} \text{Mr. L. Williams, M.B.E., to 24-10-28.} \\ \text{Major C. H. Tresham, from 25-10-28 to 3-5-29.} \\ \text{Mr. J. C. C. Lears, from 4-5-29.} \end{array} \right.$

104. General.—This detachment, with its name changed from the 1st October 1928 from Rājputāna to Benares Detachment, undertook special city surveys in Benares on 16-inch and 64-inches = 1 mile scales in sheets 63 K and O and a special survey on the 16-inches = 1 mile scale in sheet 45 B in Jodhpur State. The field head-quarters were at Benares Cantonment.

Personnel.—The field strength, excluding the Officer in charge, was one Class II officer, 2 U. S. S. officers, 34 surveyors, 2 draftsmen, 2 computers and 3 traversers. A pupil surveyor and a traverser were discharged during the field season as unsuitable.

105. Areas Surveyed.—369 acres of 16-inch original survey in sheet 45 B in Jodhpur State.

1,862 acres of 16-inch and 2,165 acres of 64-inch original city survey in Benares.

335 supplementary traverse stations laid down for 64-inch, and 1,377 traverse stations re-laid for 16-inch and 64-inch survey in Benares City.

The framework for the 6-inch survey of the Benares Guide map comprising a traverse of 78 linear miles with 429 stations was laid down.

106. Field work was organized as follows:—

Camp (1).—Mr. H. H. P. Butterfield (Class II), with 17 surveyors (increased to 20 in March), surveyed 1,164 acres on the 16-inch, and 1,097 acres on the 64-inches = 1 mile scale in Benares City. The 64-inch area covering for the most part the heart of the city was very congested and difficult to survey.

Camp (2).—Mr. J. M. Mukerjee (U. S. S.), with 19 surveyors (decreased to 16 in March), surveyed 698 acres on the 16-inch, and 1,068 acres on the 64-inches = 1 mile scale in Benares City.

Camp (3).—Mr. D. S. Gandhi (U. S. S.) with 2 computers and 3 traversers laid down 429 traverse stations for the 6-inch survey of the Benares Guide Map, 335 supplementary traverse stations for the 64-inch survey of Benares City, and relaid 1,377 traverse stations in the area of Benares covered by the 16- and 64-inch surveys.

Surveyor Tula Ram, whose work was situated at a great distance from the main area of the detachment, surveyed 369 acres on the 16-inches = 1 mile scale in sheet 45 B. Contours were shown at intervals of two feet.

107. Recess duties.—Fair mapping was divided into three sections under Messrs. Butterfield, Alexander and Mukerjee. The mapping of all field work was completed during the year.

Mr. D. S. Gandhi completed the computations of traversing for the Benares Guide Map.

Bhopal Survey Detachment

Officer in charge.—Rai Sahib Chuni Lal Kapur.

108. General.—The detachment continued work on mapping on the 16-inches = 1 mile scale and on the preparation of *mujhmils* on the 1-inch = 1 mile scale in sheets 54 L and 55 E.

Triangulation and boundary traverse for the survey on the 2-inches = 1 mile scale of all forest blocks in the state covering approximately 1,400 square miles were undertaken in advance. The detail survey of this area and a survey of Bhopal City of approximately 800 acres on 64-inches = 1 mile scale are to be commenced next field season.

By arrangement with the Revenue Member, the detachment was inspected by the Director, Central Circle, once during the field season.

Air Survey Traverse Detachment

Officer in charge.—Mr. Ram Narayan Hastir.

109. General.—This detachment was formed in November 1928 for the air survey by the Indian Air Survey and Transport Limited for 16-inch settlement surveys in the Sitāpur, Bahraich and Fyzābād districts in the United Provinces in sheets 62 H, 63 A, E, F, I, J and N. The field head-quarters were at Sitāpur.

Personnel.—The field strength, apart from the Officer in charge, was 1 U. S. S. Officer, 16 traversers and 7 computers, and one draftsman.

Outturn.—3,796 linear miles of traversing in sheets 62 H, 63 A, E, and I in the Sitāpur and Bahraich districts were completed.

110. Field work was organized as follows:—

Camp (1).—Head-quarters Sitāpur. Mr. R. N. Hastir, with 8 traversers, completed 1,798 linear miles of traversing in the Sitāpur district.

Camp (2).—Head-quarters Bahraich. Mr. Jagan Nath, with 8 traversers, completed 1,998 linear miles of traversing in the Sitāpur and Bahraich districts.

The country consists partly of open cultivation interspersed with numerous villages and mango groves, and partly of broken ground covered with high grass, scrub and sand-hills along the banks of the Gumti, Gogrā and Sarāyān rivers.

111. Recess duties.—Computations under Messrs. Hastir and Jagan Nath were completed during the year; and photographs of the remainder of the area to be completed next season were examined and docketed.



COLONEL C.M. BROWNE, C.M.G., D.S.O., R.E.,
DIRECTOR, SURVEY OF INDIA.

Born at Dharwar on
26th November 1878.

Died at Bangalore on
29th August 1929.

VII.—SURVEY REPORTS, SOUTHERN CIRCLE

DIRECTOR:—
 Lt.-Col. L. G. Crosthwait, I.A., up to 23-10-28.
 Major R. S. Wauchope, O.B.E., I.A., (officiating from 24-10-28 to 14-11-28).
 Colonel C. M. Browne, C.M.G., D.S.O., B.E., from 15-11-28.

112. Summary.—The units administered by the Southern Circle were Nos. 6, 7 and 8 Parties and No. 4 Drawing Office.

113. Training.—10 pupil surveyors and 2 pupil draftsmen were entertained during recess and attached to parties and No. 4 Drawing Office.

114. Special surveys.—Large-scale surveys were carried out for private estates.

115. The field work of parties, of which the outturn on the normal 1-inch = 1 mile scale was 14,008 square miles covering 53 sheets, was as follows:—

No. 6 Party.—Topography in sheet 56 J, N, 65 G and 66 E on the scale of 1-inch = 1 mile, forest surveys on the 2-inches = 1 mile scale in sheet 65 G and 12-inches = 1 mile and larger scales of archaeological survey of Māndu Fort and revision of the 16-inches = 1 mile map of Bangalore Civil and Military Station.

No. 7 Party.—Topography on the scale of 1-inch = 1 mile in sheets 48 N, 48 O and 57 B. C. 16-inches = 1 mile surveys of estates in sheet 48 O.

No. 8 Party.—Topography on the scale of 1 inch = 1 mile in sheets 58 J and N. 3-inches = 1 mile survey for Guide Maps in sheets 58 J, K, N. Survey of estates in sheets 58 A, B, C, and G on scales of 16-inches = 1 mile and 1-inch = 40 feet.

116. Sale of Maps.—The sale of maps progresses very satisfactorily, the amount realized during the year being Rs. 9,660; mounting charges totalled Rs. 2,213.

No. 6 Party

Officer in charge.—Major R. S. Wauchope, O.B.E., I.A.

117. General.—The party opened its field headquarters office at Secunderābād on the 10th December 1928 and continued topographical surveys in Hyderābād State and Madras.

Personnel.—The field strength of the party was 1 Class I, 2 Class II, 4 Upper Subordinate and 44 Lower Subordinate Officers, and 1 Class II Probationer.

118. Areas surveyed.—A total area of 4,874 square miles was surveyed as follows:—

4,245 square miles original and 235 square miles supplementary survey on the 1-inch = 1 mile scale in sheets 56 J, 56 N, 65 G and 66 E and 394 square miles on the 2-inches = 1 mile scale in sheet 65 G.

Archæological surveys of Māndu Fort and groups of Buddhist caves in Western India on twelve-inch and larger scales have been done and the party also carried out revision of the sixteen-inch map of Bangalore Civil and Military Station and traverse work preliminary to revision of Hyderābād City survey.

119. Field work was organized as follows:—

Topographical Surveys. Camp (1), under Mr. E. N. Natesan, B.A., (Class II), assisted by Mr. J. A. Cabral (U. S. S.) and a staff of 18 surveyors and a Class II probationer completed 1,875 square miles on the 1-inch = 1 mile scale, and 394 square miles on the 2-inches = 1 mile scale for the Madras Forest Department. The disputed boundary between the Mahārāja of Pithāpuram and the adjoining zamindār was settled by arbitration, the Officer in charge of this camp being the arbitrator.

The country consisted of low-lying cultivated flat country with second-class forest-land and palmyras in the south rising to densely covered jungle-clad hills in the north. This area is very unhealthy and sparsely populated and great tact was required in dealing with the local inhabitants of the Agency Tracts, which are backward areas under special administration.

Camp (2), under Mr. C. P. E. Davenport (Class II), assisted by Mr. Muhammad Abdul Azim, I.D.S.M., (U. S. S.), and a staff of 18 surveyors completed 2,542 square miles original survey on the 1-inch = 1 mile scale. The country varied from open cultivated plains to undulating hills thickly covered with jungle. This camp closed early in April and proceeded to Bangalore forming an advance section for the preparation of blue prints and mosaics. In this way drawing was well in hand and the first sheets were ready for the drawing office by the beginning of July.

Camp (3), consisting of 1 Upper Subordinate Officer and 4 surveyors directly under the supervision of the Officer in charge of the party, carried out 3,250 square miles of triangulation in sheets 65 F, J and K; and traverse work for forest surveys in sheet 65 G and in 66 E and A, for plane-table works and completed 63 square miles on the 1-inch = 1 mile scale in 66E/1. As in the previous year some difficulties and discrepancies have arisen regarding the position of trijunction points, data of which were given by the Madras Revenue Survey.

Triangulation.—An area of 3,250 square miles was triangulated by surveyors Mohkam Chand, A. Shamanna and A. Narasingha Rao in part of the Agency Tracts of Madras falling in the Godāvāri and Vizagapatam districts. The triangulation in sheets 65 F, J and K has been connected with the geodetic series Nos. 43, 46 and 58. The country is very mountainous with thick jungle, and head-loads are the only means of transport in a large part of the country. Provisions are not available locally and had to be brought from towns some distance away.

Traversing.—Messrs. K. B. Muthanna and Muzaffar Husain (U. S. S.) and surveyor Mohkam Chand completed 55 linear miles of theodolite traverse covering an area of 97 square miles in sheet 65 G.

Special surveys.—Surveyors Dhondli Masku Banker and Bal Kishan Lal carried out the survey of Buddhist caves in Western India and Māndu Fort on 12-inches = 1 mile and larger scales.

120. Recess duties.—Fair drawing was organized in 3 sections under Messrs. Natesan and Davenport and the Officer in charge of the party. The fair mapping of 19 one-inch, 4 half-inch and 13 two-inch sheets were completed. 4 special sheets of various Buddhist cave areas were also drawn and submitted. Surveyor Narasinga Rao and 2 computers completed the computations of the triangulation.

121. Map sales.—A fairly large business was done during the year both with the military authorities and official departments of Hyderābād State. Efforts to increase the sales to private individuals were successful. Camp officers had interviews with local officials in East Godāvāri District in Madras to popularize the use of maps.

No. 7 Party

Officer in charge.—Captain G. W. Gemmell, I.A.

122. General.—With field headquarters at Shimoga in the district of that name the party continued the 1-inch topographical survey of Madras and Mysore State, completing between 25th November 1928 and 30th April 1929 4,919 square miles of original and supplementary survey, 1,106 acres (on payment) of private estates on 16-inches = 1 mile scale, and 4,014 square miles of supplementary triangulation.

Personnel.—Field strength was one Class I and three Class II officers, one probationer Class II, 4 Upper Subordinate Service and 23 Lower Subordinate Service officers, and 7 pupils. This establishment remained unaltered during the recess except for the retirement of Mr. Abdul Ghafur on 1st September 1929 and the transfer of one surveyor to the Drawing Office.

123. Field work.—For the survey of the 17 one-inch sheets in 48 O, N and 57 B, C, totalling 4,919 square miles, the party was organized in 3 Camps as follows:—

Camp (1), Mr. Pilcher (Class II), one Class II probationer, 1 U. S. S. officer, 8 surveyors; 1,443 square miles in 48 N and O.

Camp (2), Mr. Mandanna, a second U. S. S. officer, and 10 surveyors; 1,456 square miles in 48 N and O, 57 B and C.

Camp (3), Mr. Harihara Iyer (Class II), 11 surveyors; 2,020 square miles in 57 B and C.

One surveyor was engaged on the estate surveys in Kadūr District throughout the season.

Mr. Murthy (Class II) and Mr. Mohabat Ali (U. S. S.), joined later by Mr. Ponnappa (U. S. S.) from Camp I, were employed on supplementary triangulation in 48 M, N and J between 21st November 1928 and 25th May 1929, in preparation for next year's 1-inch topographical programme.

The country surveyed for the most part consisted of open undulating plateau, averaging under 3,000 feet elevation, with sparsely wooded rocky ranges rising in the northern portion of Kadūr District to 6,000 feet. Densely wooded plateau and ranges of an average elevation of 3,000 feet were met in the N. W. portion of Kadūr and in parts of Shimoga District known as the Malnād. The Malnād districts are malarious and unhealthy for three months after the monsoon.

124. Miscellaneous.—Weather conditions remained generally favourable throughout the field season. Towards the end of April heavy unexpected showers commenced which hampered both surveyors and triangulators. In the field the health of the party was very good, but on return to recess several surveyors who had been working in the Malnād had severe attacks of fever. There was one casualty among menials, one

khalāsi dying from pneumonia in Hāveri. Several cases of hook-worm among khalāsis were reported from this locality. All khalāsis recruited were medically examined prior to recruitment.

125. Recess duties.—Mapping of the 17 one-inch and 3 half-inch sheets and four estate maps was completed by three drawing sections under Messrs. F. C. Pilcher, N. S. Harihara Iyer and K. G. Mandanna. A section under Mr. Murthi computed the supplementary triangulation carried out by the party during the field season.

No. 8 Party

Officer in charge.—{ Mr. S. Fielding from 1-10-28 to 20-5-29.
Major C. H. Tresham from 21-5-29.

126. General.—The party continued normal topographical surveys on the 1-inch = 1 mile scale in the Madura, Rāmnād, South Arcot Tanjore and Trichinopoly districts, Pudukkottai State and French territory of Pondicherry and in addition undertook the following:—

Special estate surveys on the 16-inches = 1 mile scale in the Coimbatore, Malabar and Nilgiri districts and Travancore State.

Surveys for guide maps on the 3-inches = 1 mile scale of Kumbakonam, Madura, Tanjore and Trichinopoly.

A boundary survey of military land on the scale of 12-inches = 1 mile at Podanūr in the Coimbatore district.

A survey on the scale of 1-inch = 40 feet of the Cowdrey estate at Ootacamund.

Survey on the 1-inch = 1 mile scale of a new railway line in the Rāmnād and Trichinopoly districts.

In addition, points were fixed and distances measured for range testing at Trichinopoly, where field headquarters were situated.

Personnel.—The field strength, apart from the Officer in charge, was 3 Class II officers, 3 Upper Subordinate Service officers and 53 surveyors, etc.

127. Areas surveyed.—Original topographical survey 1,283 square miles on 1-inch = 1 mile scale.

Supplementary topographical survey 3,326 square miles on 1-inch = 1 mile scale.

Supplementary guide map survey 77 square miles on 3-inches = 1 mile scale.

Revision guide map survey 23 square miles on 3-inches = 1 mile scale.

16-inch original estate survey, 22,138 acres.

12-inch original boundary survey, 250 acres.

One-inch to 40 feet estate survey, 14 acres.

One-inch railway survey, 87 miles.

Triangulation, 918 square miles.

Traversing, 3,495 square miles.

128. Field work was organized as follows:—

Camp (I).—Mr. B. T. Wyatt (Class II) with 13 surveyors triangulated 24,102 acres and surveyed 22,138 acres of tea estates on the 16-inches = 1 mile scale in the Coimbatore, Malabar and Nilgiri districts and Travancore State.

Camp (2).—Mr. M. S. Ganesa Aiyar (Class II) with 11 surveyors completed 256 square miles of original and 1,371 square miles of supplementary survey on the 1-inch scale and 27 square miles of supplementary survey on the 3-inch scale.

Camp (3).—Mr. S. R. Kelkar (Class II) with 9 surveyors completed 211 square miles of original and 1,263 square miles of supplementary survey on the 1-inch scale.

Camp (4).—Mr. P. S. Vengusvami (U. S. S.) with 9 surveyors completed 816 square miles of original and 692 square miles of supplementary survey on the 1-inch scale, also 31 linear miles of railway survey on the same scale.

Camp (5).—Mr. Saiyid Budhan (U. S. S.) with 2 surveyors completed 40 square miles of triangulation, 50 square miles of supplementary and 23 square miles of revision survey on the 3-inch scale, also 250 acres of boundary survey on the 12-inch scale and 56 linear miles of railway survey on the 1-inch scale.

Triangulation and traversing.—Mr. H. Narasimhamurthi Rao (U. S. S.) with 5 traversers completed 3,495 square miles of traversing and 840 square miles of triangulation, he also traversed and surveyed the Cowdrey estate consisting of 14 acres in the Nilgiris on a scale of 1-inch = 40 feet.

129. Miscellaneous.—The area surveyed on the 1-inch = 1 mile scale for the most part consisted of paddy cultivation covered with palmyra and coconut palms; visibility was poor.

The health of the party was not good, several surveyors and khalāsis suffering from malaria and one surveyor was invalided from the field. During the early part of the season cholera in epidemic form was prevalent in the area under survey and two menials died of it.

130. Recess duties.—Fair mapping was divided into 4 sections under Messrs. Wyatt, Ganesa Aiyar, Kelkar and Vengusvami. The mapping of all field work was completed during the year, and the drawing of two $\frac{1}{2}$ -inch sheets, 58 J/NW. and J/SW., was undertaken. Mr. H. Narasimhamurthi Rao was in charge of the computing and compiling section which completed the computations of all triangulation and traversing done during the field season and prepared the plane table sections required for the coming winter.

VIII.—SURVEY REPORTS, EASTERN CIRCLE

DIRECTOR:—{Colonel A. A. McHarg, D.S.O., R.E., up to 2-2-29.
Lt.-Colonel J. D. Campbell, D.S.O., R.E., from 2-2-29.

131. Summary.—The units administered by the Eastern Circle were Nos. 4, 9 and 12 Parties, and No. 5 Drawing Office.

The Director, Eastern Circle also acts as Director of Surveys, Assam, under the local government. This entails the administration of the Assam *Traverse Party*, the Assam *Drawing and Reproducing Offices* at Shillong, and the Assam *Survey School* at Jhālukkāri.

In addition, as technical adviser to the Governments of Bengal and Bihār and Orissa, the Director, Eastern Circle, visited the Bengal Survey School at Mainamāti near Comilla, the Bihār and Orissa Drawing Office at Gulzārbāgh (Patna) and the Assam Survey School at Jhālukkāri (Gauhati). Whilst at Patna, he conferred with the Chief Engineer, Irrigation Department regarding surveys on the Orissa Coast and with the Director of Land Records, Bihār and Orissa. He also conferred with the Government of Bengal regarding the Mālda Air Survey and visited the offices of the Air Survey Company in Calcutta.

132. *The field work* of parties covered 53 one-inch sheets partly or wholly surveyed, as follows:—

No. 4 Party.—Topography 3,838 square miles on the 1-inch = 1 mile scale in sheet 72 H and 73 E.

No. 9 Party.—Topography 3,962 square miles on the 1-inch = 1 mile scale in sheets 73 J, K, L, P and 74 I.

No. 12 Party.—Topography 4,934 square miles on the 1-inch and $\frac{1}{2}$ -inch = 1 mile scales in sheets 78 E, F, G, I, J and K.

Training.—Most of the pupils attached for training to parties in the field, appear to be promising and likely to become useful surveyors. Only two pupils were discharged during the year.

133. *Air Survey of Mālda district.*—The maps produced during the year by the Air Survey Company, did not prove entirely satisfactory and unexpected technical difficulties arose both as regards compilation and as regards their suitability for settlement purposes. The result of this has been that the original contract was not completed.

In order to ensure accuracy, it has been found necessary to rectify each photo by the aid of traverse points along its edges. The difficulties from the settlement point of view have also, it is hoped, been surmounted and all maps produced by the new method have proved quite accurate and satisfactory when tested in the field.

The Bengal Government, in spite of the initial set-back, was willing to give air-survey a further trial and it is hoped that the result of final experiments on a large scale will lead to a new contract being entered into for the rest of the work in the Mālda district and to air survey being adopted for settlement work in other districts.

No. 4 Party

Officer in charge.—Major F. B. Scott, I.A.

134. General.—Supplementary survey on the 1-inch = 1 mile scale was carried out in sheets 72 H and 73 E, in Bihār and Orissa. Field headquarters were at Hazāribāgh.

Personnel.—The field strength of the party was 3 Class II officers 3 Upper Subordinate Service officers and about 33 Lower Subordinates.

135. Areas surveyed.—

1-inch supplementary survey 3,838 square miles.

Triangulation—1,113 square miles.

Traversing.—2,360 square miles.

Levelling.—180 square miles.

136. Field work was organized as follows:—

Camp (1).—Mr. S. F. Norman (Class II) assisted by Mr. Abdul Aziz Khan (U. S. S.) with 5 surveyors and 6 pupils carried out supplementary survey on the 1-inch=1 mile scale of 1,084 square miles in the open cultivated plains of Gayā district and on the Chotā Nāgpur plateau and the densely-wooded scarp between them. There is a large number of mica mines in the area north of Kodarmā.

Camp (2).—Mr. H. H. Creed (Class II) with 10 surveyors carried out supplementary survey on the 1-inch=1 mile scale of 1,398 square miles on the Chotā Nāgpur plateau, comprising wooded hills and plains and areas of open cultivation. The Bokāro coalfield falls in the area.

Camp (3).—Mr. A. C. Maulick (U. S. S.) with 8 surveyors carried out supplementary survey on the 1-inch=1 mile scale of 1,356 square miles in the open cultivated plains of Gayā district and on the Chotā Nāgpur plateau. All wooded areas are being steadily denuded and wild life destroyed, though some attempt is now being made to preserve both.

Traverse camp.—Mr. N. C. Roy (U. S. S.) with 4 traversers carried out traversing in the Bānkurā, Bīrbhūm and Burdwān districts of Bengal, consisting of flat cultivated ground with patches of jungle.

Triangulation.—Mr. A. R. Quraishi, B.A., (Class II) and Mr. N. C. Roy were employed on triangulation, the former on the Chotā Nāgpur scarp and the latter in Bankurā district of Bengal.

Levelling.—Mr. A. R. Quraishi, B.A., (Class II) carried out 63 linear miles of levelling in the plains of Gayā district.

137. Forest surveys.—The 1-inch survey included supplementary survey on the 1-inch=1 mile scale of 18 square miles in the Kodarmā reserved forest and the Kodarmā, Partango, Birjamu and Pathaldiha protected forests of the Hazāribāgh forest division.

138. Recess duties.—The fair-mapping, consisting of 15 one-inch sheets, was divided into three sections under Messrs. Norman, Creed and Maulick and was completed before the end of recess.

Triangulation and traverse computations were completed by a section under Mr. N. C. Roy.

No. 9 Party

Officer in charge.—{ Mr. P. A. T. Kenny, O.B.E., to 27-10-28.
Mr. V. W. Morton, from 28-10-28.

139. General.—The following programme was carried out:—Original survey on the 1-inch=1 mile scale in sheets 73 K, L and P and 74 I and survey of a portion of re-alignment of Chaibāsa Ghātsila road in sheet 73 J, in Bihār and Orissa. Field headquarters were at Cuttack.

Personnel.—The average field strength of the party was 2 Class II officers, 1 Class II officer (on probation), 5 Upper Subordinate Service officers and 40 Lower Subordinates.

140. Areas surveyed.—One-inch original survey 3,962 square miles.

Triangulation.—4,147 square miles.

Traversing.—1,398 square miles.

141. Field work was organized as follows:—

Camp (1).—Mr. John McCracken, M.B.E., (Class II), with one Class II probationer, one instructor, 11 surveyors and 4 pupils, carried out original surveys on the one-inch = 1 mile scale of 1,668 square miles in the Balasore and Cuttack districts and Dhenkānāl and Keonjhar Feudatory States of Orissa.

The country surveyed comprises partly broken hilly regions covered with sāl forest and partly arable areas of rice-land, intersected by the Brāhmani, Baitarani, Kharsua and Sālandi rivers, from which navigable canals and numerous minor canals emanate. The greater part of this latter area is liable to floods.

Camp (2).—Mr. Bhupendra Nath Saha, M.Sc., (Class II), with 11 surveyors carried out original survey on the 1-inch = 1 mile scale of 1,273 square miles in the Cuttack and Puri districts, consisting, in the coastal area, partly of a marshy jungle covered strip averaging 3 miles in width along the sea-coast and partly of a strip of sand-dunes about 2 miles in width; and inland, of arable areas of rice-land in the Mahānadi delta. These areas are intersected by an elaborate system of canals, the chief of which are the Māchgaon, Tāldanda, Kendrāpāra and Gobri canals.

Camp (3).—Mr. Rohini Kumar Talapatra, B.A., (U. S. S.), with 7 surveyors and one pupil, carried out original surveys on the 1-inch = 1 mile scale of 1,021 square miles in the Balasore and Cuttack districts. The area was mainly a coastal strip, whose swamps, dense jungle and noxious climate resemble the same features in the Sundarbans. It is intersected by innumerable tidal creeks and streams, which rendered the survey difficult. The tract is low lying and remains under water for about six months in the year. Air-photographs of a strip from three to five miles wide along the sea coast, reduced to the scale of the survey, greatly facilitated the survey of the swampy mangrove areas.

Triangulation.—Messrs. Satish Chandra Mukerjee, Muhammad Siddik, Hiranya Kumar Kar and Nirmal Chandra Sen (U. S. S.), triangulated in the Cuttack and Puri districts of Bihār and Orissa, Ganjām district of Madras, and in Feudatory States of Orissa. The areas consists for the most part of a succession of dense jungle-clad ranges, with narrow valleys containing scattered patches of terraced rice, cultivation, the whole being drained by the Brāhmani and Mahānadi rivers. A low range of bare isolated hills running in a south-west direction towards the Chilka Lake fills the rest of the area.

Traversing.—Traversing for one-inch survey was carried out in the alluvial plains forming the south-western portion of the Mahānadi delta. The computations were done *pari passu* by two computers at field headquarters.

Forest surveys.—No Government reserved forests fall within the sphere of survey operations.

City surveys.—One surveyor was attached to the Map Publication Office for employment on the revision of the six-inch Guide Map of Calcutta and Howrah.

142. Recess duties.—The fair mapping, consisting of 17 one-inch sheets was divided into 2 sections under Messrs J. McCracken, and Bhupendra Nath Saha, assisted by 3 Upper Subordinate Service officers, and was completed during recess.

The computing of the triangulation was completed by Mr. Satish Chandra Mukerjee (U. S. S.) assisted by Mr. Muhammad Siddik (U. S. S.) and 5 computers.

No. 12 Party

Officer in charge.—Major H. R. C. Meado, I.A.

143. General.—The following programme was carried out:—Original survey on the $\frac{1}{2}$ -inch=1 mile and 1-inch=1 mile scales in sheets 78 E, F, I, J and K in Assam, Bengal and Bhutān; supplementary survey on the 1-inch=1 mile scale in sheets 78 F, G and K in Assam and Bengal; triangulation and traverse in sheets 72 M, 78 A, B and F and 83 H.

Field headquarters were at Jalpaiguri.

The old maps superseded by the above supplementary survey were based on cadastral surveys 15 years old and on forest surveys 35 years old. The maps of the rest of the area, excluding Bhutān, were from 55 to 70 years old. The Bhutān area had never been surveyed before.

Personnel.—The field strength of the party was 3 Class II officers (including one probationer), 2 Upper Subordinate Service officers and about 45 Lower Subordinates.

144. Areas surveyed.—

Half-inch original survey 1,839 square miles.

One-inch original survey 547 square miles.

One-inch supplementary survey 2,548 square miles.

Triangulation.—3,500 square miles.

Traversing.—2,100 square miles.

145. Field work was organized as follows:—

Camp (1).—Mr. E. M. Kenny (Class II) with 11 surveyors; carried out original and supplementary surveys on the $\frac{1}{2}$ -inch=1 mile and 1-inch=1 mile scales of 1,549 square miles in the Goālpāra district of Assam, Jalpaiguri district and Cooch Behār State of Bengal, and Bhutān.

The Bhutānese *Durbār* very kindly permitted our surveyors to cross the frontier, and this resulted in the survey of 790 square miles of previously unexplored country.

The area falling in the plains, surveyed by this camp, comprises the Bengal *Duārs*, ceded by Bhutān after the Bhutān war of 1864, consisting entirely of Government forests and tea-gardens. Like the neighbouring Bhutān foot-hills, it is inhabited mostly by Gurkhas, except around Buxa, which is the only Bhutānese colony in British India.

The Himālayan foot-hills in Bhutān are extremely rugged, and rise from 500 feet above sea-level at the frontier to over 13,000 feet in less than 15 miles.

The whole country teems with game.

Camp (2).—Mr. R. C. Hanson (Class II) with 10 surveyors carried out original and supplementary surveys on the $\frac{1}{2}$ -inch=1 mile and

1-inch=1 mile scales of 2,160 square miles in the Gāro Hills, Khāsi and Jaintiā Hills, and Sylhet districts of Assam, and the Mymensingh district of Bengal.

The northern edge of this camp's area is the main range of the Gāro Hills, 4,000 feet in height. South of these hills, which abound in game, are the over-populated plains of Mymensingh, only a few feet above sea-level, water-logged throughout the year, and devoted exclusively to jute cultivation.

Camp (3).—Mr. Moti Lal Roy with 10 surveyors carried out original and supplementary surveys on the 1-inch=1 mile scale of 1,225 square miles in the Jalpaiguri and Rangpur districts and Cooch Behār State of Bengal, and the Goālpāra district of Assam.

This camp's area was flat cultivated plains lying south of Camp (1).

Triangulation.—The connection of the base of last year's triangulation in Bhutān with three G. T. stations in the Cooch Behār plains, 40 miles distant, was completed in the plains by Mr. S. C. Chatterjee and surveyor Pentenduk, and in Bhutān by surveyor Hari Datta. The services of Pentenduk were lent by the Bhutanese *Durbār*.

The ends of the Bhutān base were fixed with a maximum error of 10 feet.

Surveyors Hari Datta and Pentenduk afterwards triangulated portions of Sikkim, Bhutān, and Darjeeling district of Bengal. Mr. Chatterjee triangulated in Manipur State, Lushai Hills and Cāchār districts of Assam and the Chin Hills district of Burma.

Traversing.—Four traversers completed nearly one year's detail survey programme area (including forest surveys) in the Darjeeling, Dinajpur and Jalpaiguri districts of Bengal and the Purnea district of Bihār.

Forest surveys.—55 square miles of new 4-inch forest survey in the Jalpaiguri district had to be postponed, as the Bengal Government was unable to guarantee payment.

The $\frac{1}{2}$ -inch and 1-inch survey included 237 square miles of reserved forests in the Goālpāra and Gāro Hills districts of Assam and the Jalpaiguri district of Bengal.

Miscellaneous.—Health was fair, except in the low-lying Mymensingh area.

One surveyor died of dysentery, one khalasi of cholera and eight khalasis of malaria.

146. Recess duties.—Fair-mapping, consisting of 13 one-inch and 3 half-inch sheets, was divided into three sections under Messrs. Kenny, Hanson, and Moti Lal Roy, and was completed before the end of recess.

Mr. Chatterjee was in charge of the Computing Section, and completed the triangulation and traverse computations.

IX—SURVEY REPORTS, BURMA CIRCLE

DIRECTOR:—{ Colonel E. T. Rich, C.I.E., R.E., up to 13-5-29.
Lt.-Colonel H. T. Morshead, D.S.O., R.E., from 14-5-29.

147. Summary.—The units administered by the Burma Circle were Nos. 10, 11 and 21 Parties and No. 7 Drawing Office.

148. Training.—Twenty pupil surveyors were under training in the Circle, of whom two were discharged as unlikely to become efficient surveyors. In addition 9 pupils were enlisted during recess and were attached to No. 7 Drawing Office for preliminary instruction in drawing.

149. The field work of parties was as follows:—

No. 10 Party.—Topography on $\frac{1}{2}$ -inch = 1 mile, 1-inch = 1 mile and 4-inches = 1 mile scales in sheets 83 N, 85 J, N & O, and 92 F.

No. 11 Party.—Topography on 1-inch = 1 mile, $1\frac{1}{2}$ -inches = 1 mile, 2-inches = 1 mile and 4-inches = 1 mile scales in sheets 85 P, 94 C & D.

No. 21 Party.—Survey of reserved forests on 4-inches = 1 mile scale in two Forest Divisions of the Northern Forest Circle.

150. Maymyo Guide Map.—A guide map to Maymyo, on the $\frac{1}{20,000}$ scale was compiled in No. 7 Drawing Office from surveys on the 4-inches = 1 mile scale and was submitted for publication in May.

No. 10 Party

Officers in charge:—{ Mr. D. K. Rennick, M.B.E., to 8-10-28.
Major T. M. M. Penney, R.E., from 9-10-28 to 8-3-29.
Captain G. F. Heaney, R.E., from 9-3-29.

151. General.—The party carried out topographical surveys on the 1-inch = 1 mile scale in the Arakan Yomas in sheet 85 J, and completed a special survey on the 4-inches = 1 mile scale for the P.W.D. in connection with a drainage project in sheets 85 N and O.

Topographical surveys were also carried out on the $\frac{1}{2}$ -inch = 1 mile scale in conjunction with expeditions in 83 N and 92 F.

The field headquarters of the party opened at Rangoon on 6th November 1928.

152. Personnel.—The field strength of the party comprised 3 Class II, 5 Upper Subordinate and 31 Lower Subordinate Officers.—

153. Areas surveyed.—The party surveyed a total area of 2,843 square miles in the Sandoway, Henzada, Prome, Tharrawaddy and Thayetmyo districts in sheets 85 J, N and O, and of 1,543 square miles in tribal territory.

The area comprised 1,543 square miles of original $\frac{1}{2}$ -inch survey, 2,520 square miles of supplementary 1-inch survey, and 323 square miles of original 4-inch survey for the P. W. D. 246 linear miles of secondary levelling and 1,360 linear miles of tertiary levelling were carried out by the Levelling Detachment in connection with the last survey.

154. Field work was organized as follows :—

Camp (1) under Mr. D. K. Rennick, carried out the supplementary survey of 1,140 square miles on the 1-inch = 1 mile scale.

Camp (2) Under Mr. G. A. Norman, carried out supplementary survey of 1,126 square miles on the 1-inch = 1 mile scale.

The country surveyed lay astride the main ridge of the Arakan Yomas and consisted of hills rising from nearly sea-level to upwards of 4,000 feet, covered with dense jungle. Tracks and villages were few and far between, and communication and supplies presented considerable problems. Towards the end of the season shortage of water added to the difficulties of the surveyors. The positions of the only two possible places for headquarters for camps, and the difficulty of crossing the Yomas, except by one route, made it necessary to allot to each camp an area covering a degree from north to south. This arrangement involved long and arduous marches for camp officers inspecting their surveyors, and made frequent inspections impossible.

Camp (3) under Mr. F. E. R. Calvert carried out supplementary survey of 254 square miles of 1-inch survey near the Myanaung Plain.

U. Pe and surveyor Maung On Ba working in tribal territory in sheet 92 F carried out original survey on the $\frac{1}{2}$ -inch = 1 mile scale of 629 square miles.

Surveyors Amar Singh and Narayan Singh carried out original survey on the $\frac{1}{2}$ -inch = 1 mile scale of 914 square miles in sheet 83 N. As these surveyors were accompanying an expedition where fixings could only be made along the line of march and only a very limited time was allowed at each fixing, both worked from the same fixings, dividing the country between them and thus halving the time that would have been taken by one surveyor working alone.

155. Special Surveys.—Camp (3) under Mr. F. E. R. Calvert carried out a 4-inch original survey of 323 square miles in the vicinity of Myanaung. The object of this survey was to produce a map which would show accurate ground heights at close intervals over the whole area. To effect this, lines of pegs at intervals of 1,250 feet by 750 feet, were fixed by the surveyors during the course of their work. The levelling detachment afterwards went over the area and fixed the ground height of each of these pegs, and this value is given on the finished sheet. Surveyors showed the shape of any small irregularities in the surface of the ground by form lines; and with the assistance of these, and by interpolating between fixed heights, contours at one-foot interval were drawn during recess. With the exception of a range of hills about six miles long and rising about a hundred feet above the surrounding country, the area consisted of level plain, cultivated for the most part, with numerous villages and containing large shallow depressions liable to flood. These depressions were generally filled with thick grass through which surveyors had to cut their way in order to lay out their lines of pegs. The necessity for cutting these lines at frequent intervals greatly reduced the rate of outturn for the detailed survey. Later while levelling was in progress, a pupil surveyor, with the planetable section of the area, was attached to each levelling squad to locate pegs.

156. Miscellaneous.—Man-eating tigers are numerous on the western slopes of the Yomas, especially in the vicinity of the Padaung-Taungup road, and about February become particularly bold. Two coolies in Camp (1) were killed by them. On the first occasion the tiger carried off a cooly from the middle of a camp of about 40 men. Alarmed by the cries of the others it dropped the man after going a short way, but soon afterwards returned and ignoring the shouts of the whole assembled camp, entered a surveyors' tent and pulled about his bedding in search of another victim. The injured cooly subsequently died.

On the second occasion two Kachin coolies were on their way to camp headquarters. Being unable to reach a village by nightfall they built themselves a *machān* in a tree about six feet above the ground and went to sleep on it. Towards morning one of them was seized by a tiger and dragged to the ground. His companion managed to frighten off the tiger and then leaving the wounded man, who was unable to walk, near some water, he went for help. During his absence the tiger must have returned and carried off the injured cooly, as no trace of him was found on the arrival of a rescue party.

Elephants were also numerous and one man was severely injured by a fall while running away from one.

The eastern slopes of the Yomas in this area are swept by forest fires every year, commencing about the beginning of February, and from then until the rains are practically devoid of animal life.

The health of the party has been on the whole good.

157. Recess duties.—The fair mapping was divided into two sections.

Section (I) under Mr. G. A. Norman fair mapped on the $1\frac{1}{2}$ -inches = 1 mile scale, the eight 1-inch sheets surveyed in 85 J.

Section (II) under Mr. F. E. R. Calvert fair mapped the twelve sheets of special survey for the P. W. D. on the 4-inches = 1 mile scale.

No. 11 Party

Officer in charge:—Major O. Slater, M.C., R.E.,

158. General.—Field head-quarters opened at Rangoon on the 12th November and surveys were continued in the Hanthawaddy, Insein, Pegu, Rangoon Town and Tharrawaddy districts of Burma.

Triangulation and forest boundary traverse were started in advance in the Hanthawaddy and Pegu districts, as these were required for the surveys mentioned in this report.

Traverse operations for next season's work were carried out in the Bassein, Hanthawaddy, Insein, Ma-ubin, Myaungmya and Pyapon districts of Burma.

159. Personnel.—The field strength of the party was 3 Class II, 5 Upper Subordinate and 26 Lower Subordinate officers.

160. Areas surveyed.—A total area of 3,014 square miles was surveyed, consisting of 2,493 square miles on the 1-inch, 313 square miles on the $1\frac{1}{2}$ -inches = 1 mile, 6 square miles on the 2-inches = 1 mile and 202 square miles on the 4-inches = 1 mile scales.

161. Field work which closed on the 15th May, was organized as follows:—

Camp (1). Mr. G. E. R. Cooper (Class II) with 7 surveyors completed 898 square miles of supplementary survey on the 1-inch = 1 mile scale, 6 square miles of original survey on the 2-inches = 1 mile scale and 45 square miles of original survey on the 4-inches = 1 mile scale in sheet 94 C.

The country included part of the main ridge of the Pegu Yomas rising to over 2,000 feet and the broken foot-hills on either side. It is sparsely inhabited and almost entirely covered with dense forest, mostly reserved. Transport was by carts and coolies, and in places supplies and good water were scarce. Old forest maps on the 4-inches = 1 mile scale were utilized and proved very accurate. Survey was by planetable traverse, except near the main ridge, and was difficult.

Camp (2). Mr. A. F. Murphy (Class II) with 7 surveyors and 5 pupils completed 98 square miles of original, 1,442 square miles of supplementary and 55 square miles of revision surveys on the 1-inch = 1 mile scale, 88 square miles of original and 45 square miles of revision surveys on the 1½-inches = 1 mile scale in sheets 94 C and D.

The country consists of the highly cultivated alluvial plain between the mouths of the Rangoon and Sittang rivers. There are numerous tidal creeks and two low laterite ridges which terminate the Pegu Yomas. Transport was by *Sampans* and later by carts. One motor boat was hired for the camp officer. Reductions from old cadastral maps were utilized, but changes were numerous, particularly towards the coast which has extended considerably with sand and mud flats, some already covered with scrub. Survey, by interpolation, was easy, except for clinometric heights, which are unreliable where differences of five feet are significant. The work of this camp was completed early and the surveyors were re-distributed amongst the other two camps, except for a few who left the field to form an early drawing section.

Camp (3). Mr. M. R. Nair (Class II) with 6 surveyors completed 180 square miles of original survey on the 1½-inches = 1 mile scale and 154 square miles of original and 3 square miles of revision surveys on the 4-inches = 1 mile scale in sheets 85 P and 94 D.

The area included the town of Rangoon and its suburbs situated on a low laterite ridge with the paddy plain surrounding it. As mentioned in last year's report the basis of the town portion of the map was an air-photo compilation made by the Rangoon Development Trust. This proved very valuable, and it was only where control points had been insufficient that discrepancies were found. Approximate contours at 10-foot intervals were put in by clinometric height traverses between benchmarks. At the moment, Rangoon, particularly the suburbs, is developing rapidly, and a revision should be made after a few years to show the extension in the neighbourhood of the University, the wharves and the numerous residential building estates. Survey, partly by interpolation and partly by traverse, was difficult, particularly in some of the residential areas where the contours are intricate.

162. Triangulation and traversing.—An area of 600 square miles was triangulated by Messrs Ram Prasad, R.S., (U. S. S.) and Khan

Muhammad (U. S. S.), and 23 linear miles of forest boundary were traversed in sheets 94 C and D for work during the season under review.

For next season's work, an area of 3,360 square miles, involving 598 linear miles, was traversed in sheets 85 O and P by 4 U. S. S. Officers. The traverses connect across the Irrawaddy delta between stations of minor triangulation in the Arrakan and Pegu Yomas. Some 1,650 points were intersected, and with the traverse stations these will provide sufficient framework for next season's 1-inch survey.

163. Special Surveys.—Apart from the Rangoon Town survey mentioned above, three reserves in the South Pegu Forest Division were surveyed; 45 square miles on the 4-inches = 1 mile and 6 square miles on the 2-inches = 1 mile scales. These reserves are covered with a particularly dense undergrowth and the hill features are intricate. Survey by planetable traverse was tedious and progress slow.

A saw-mill and timber-yard of about 64 acres in the neighbourhood of Rangoon were surveyed on payment for the Bombay Burma Trading Corporation. A scale of 50 feet = 1-inch was adopted. Traverse and level lines were run all over the site at varying intervals not exceeding 100 feet. Buildings and details were located by offset lines from these traverses, and, after plotting from the field-books, contours at 1-foot intervals were interpolated on the ground with the help of a level.

164. Miscellaneous.—At the beginning of the season, cholera, brought by Kachin coolies from up country, broke out at headquarters. Prompt sanitary and prophylactic measures prevented the disease spreading, and only four cases, all fatal, occurred. Several cases of fever amongst surveyors in the Pegu Yomas were reported towards the end of the season, but on the whole the days lost by sickness were few.

Rangoon is a modern city, and, beyond the Shwedagon and one or two other pagodas, there is little of archaeological interest. Syriam, opposite and south of Rangoon, was one of the early sites of European occupation in Burma. Except for the ruins of an old church originally founded by an Italian bishop in 1750, no other evidences of early occupation appear to survive.

165. Recess duties.—The mapping programme comprised 15 sheets on the 1½-inches = 1 mile, 2 sheets on the 2-inches = 1 mile and 4 sheets on the 4-inches = 1 mile scales. The work was divided into three sections under Messrs G. E. R. Cooper, A. F. Murphy, and M. R. Nair. The four sheets of the Rangoon guide map required constant supervision, particularly the typing.

Mr. Hayat Muhammad, K.S. (U. S. S.) was in charge of the computations and the preparation of data for next season, all of which were completed during recess.

No. 21 (Burma Forest) Party

Officers in charge—{ Major J. H. Williams, from 12-5-29.
Mr. D. K. Rennick from 13-5-29.

166. General.—The *raison d'être* of the party is the survey of reserved forests in Burma, on scales larger than one-inch. The total cost of the party is debitable to the Government of Burma.

The party operated in degree sheets 83 P, 84 M and 92 D. The field headquarters were at Banmauk.

167. Personnel.—The field strength of the party numbered 3 Class II officers, 3 Upper Subordinate Service officers and 36 Lower Subordinate Service officers.

168. Field work was organized as follows:—

Camps (1) and (2) under Messrs. A. V. Dickson with 11 surveyors and H. M. Critchell with 2 U. S. S. officers and 11 surveyors respectively, worked in the Mansi Forest Division.

Camp (3) under Mr. Bhamba Ram with 5 surveyors and 1 pupil surveyor worked in the Kathā Forest Division.

The area surveyed by these two camps lay mostly on the western slopes of the watershed carrying the Chindwin-Kathā district boundary. The higher area varied from 3,000 to 5,600 feet, falling away towards the Nantaingwin river to about 500 feet. The whole area was densely wooded, very difficult and broken with few communications. For the rationing of squads paths had to be cut.

Camp 3 was employed in open forests well served by roads.

Mr. L. B. Fitz-Gibbon (Class II), triangulating and in charge of the *Traverse Camp*.

169. Areas surveyed.—The party surveyed a total area of 236 square miles on the scale of 4-inches = 1 mile in two Forest Divisions of the Northern Forest Circle.

Northern Forest Circle.—In the *Kathā Forest Division* an area of 69 square miles was surveyed in the Nampamaung, Nanpè, Gahè and Pile Extension IV reserves.

In the *Mansi Forest Division* an area of 167 square miles was surveyed in the Nankyin, Nansa, Nankadin and Nantaingwin reserves.

46 linear miles of plane-table traversing was done along the boundary of the Uyu reserve of the Mansi Forest Division, as the posts of the theodolite traverse run on this boundary during the previous season would scarcely have withstood another monsoon season.

170. Triangulation.—600 square miles were triangulated by Mr. L. B. Fitz-Gibbon in degree sheet 83 L. 21 stations were observed at, and though very small bases were decided on it was not possible to fix intersected points. The country fell precipitously for about a mile and gradually sloped to the Chindwin river, the area covered being densely wooded and the slopes more or less uniform. The stations fixed have been utilized for closing the theodolite traverse which was necessary in these reserves. The area triangulated covered the Thawun and northern half of the Thaungdut reserves of the Chindwin Forest Circle, and was based on the Manipur Longitudinal Series.

171. Traversing.—117 linear miles of theodolite traversing, of forest boundary and 98 linear miles of interior and connection traversing was carried out by the *Traverse Camp* to provide data for the ensuing field season. The area traversed falls in sheet 83 L of the Chindwin Forest Circle. The traverses were all connected to trigonometrical stations.

172. Miscellaneous.—The party took the field in the middle of November but, owing to an outbreak of cholera amongst the

Hazaribagh *khalāsis* en route from Sagaing to Indaw and subsequent seizures on arrival at Indaw, it was detained in quarantine till the 5th December. There were in all 37 seizures and 17 deaths.

The party medical officer, Jemadar Mahtab Singh, deserves credit for the manner in which he attended to his duties and it is due to him that the number of deaths was comparatively small.

It was owing to this most unfortunate occurrence, and the time lost in consequence, that the party was not able to complete its sanctioned programme.

Two Kachin *khalāsis* died of pneumonia.

Though wild elephants were troublesome, no casualties resulted from this source

173. Recess duties.—The fair-mapping was divided between two sections under Messrs. A. V. Dickson and H. M. Critchell.

The computation work was under Mr. L. B. Fitz-Gibbon.

The fair-mapping and computations of all the field work were completed during the year.

X.—MISCELLANEOUS SURVEY REPORTS

174. This section includes all reports of surveys not administered by the Directors of the five survey circles, such as miscellaneous surveys and commercial levelling administered by the Director, Geodetic Branch, or extra-departmental explorations, etc., in which members of the Department have taken part.

No. 20 Forest & Cantonment Office.

Officer in charge.—Mr. C. E. C. French.

175. General.—The party carries out original and revision surveys of cantonments and military lands and cantonment bāzārs as required by the Engineer-in-Chief and the Army Department.

The party is available for other special large scale surveys.

The permanent headquarters of the party are at Dehra Dūn, under the administration of the Director, Geodetic Branch.

176. Surveys.—The field section of the party, consisting of 11 surveyors and 2 computers, was under the supervision of Rai Sahib Jamna Prasad, and, between September 1928 and March 1929, completed the survey of the following cantonments on the scale of 16 inches = 1 mile, and the bāzār areas on the 64-inches = 1 mile scale :—

16-inch original survey.

Poona	200 acres
Belgaum	1,310 „

16-inch revision survey.

Poona	442 acres
Kirkee	2,547 „
Cawnpore	2,726 „
Kamptee	4,330 „
Belgaum	2,047 „
Dinapore	113 „

64-inch revision survey.

Kirkee	80 acres
Cawnpore	29 „
Kamptee	43 „
Dinapore	5 „

making a total of 13,715 acres on the 16-inches = 1 mile scale,
and 157 „ „ 64-inches = 1 mile scale.

153 linear miles of theodolite traversing were carried out in advance of the detail survey, and 60 linear miles of levelling were run at suitable intervals in the cantonments as control for 5-foot contours.

177. Special surveys.—1,000 yard zone of Belgaum Fort on the 16-inches = 1 mile scale at a cost of Rs. 2,400/-. Spot levelling in Cawnpore cantonment at a cost of Rs. 1,100/-.

178. Recess duties.—The fair maps of Delhi (Western Section and Extension), Razmak, Nowshera and part of Peshāwar, a total of 11

sheets on the 12-inch and 16-inch scales were completed for publication.

In addition 42 originals of cantonment surveys were sent to press for reprints and 4 colour guides prepared.

This work was supervised by Mr. O. D. Jackson (Class II).

No. 17 Party (Levelling).

Officers in charge.— $\left\{ \begin{array}{l} \text{Mr. N. R. Mazumdar, up to 14-10-28.} \\ \text{Dr. J. de Graaff Hunter, M.A., sc.D., F.Inst.P., from 15-10-28 to 1-1-29.} \\ \text{Lieut. I. M. Cadell, B.E., from 2-1-29 to 28-4-29.} \\ \text{Lt.-Col. C. M. Thompson, I.A., from 29-4-29 to 21-5-29.} \\ \text{Mr. H. P. D. Morton, from 22-5-29.} \end{array} \right.$

179. The high precision levelling done by this party is described in para. 32. Most of the tertiary levelling done in connection with irrigation and other projects has now been handed over to the parties doing the topographical surveys of the areas concerned.

Secondary levelling for the E. I. Railway was carried out from Cawnpore to Allahābād (128 miles) and from Mughal Sarai to Najibābād via Lucknow (481 miles); for the Punjab Government from Rohillānwāli-Alipur-Leiah (225 miles).

Tertiary and Secondary levelling for the Burma Government was carried out on the Myanaung Plain, and in Pegu District (96 miles of secondary, 1,350 miles of single tertiary and 241 miles of double tertiary).

Training School, Dehra Dūn.

Officers in charge.— $\left\{ \begin{array}{l} \text{Mr. S. F. Norman, up to 28-10-28.} \\ \text{,, L. Williams, M.B.E., from 29-10-28.} \end{array} \right.$

180. *Class I probationers.*—The following officers joined the Training School on first appointment on the dates noted against their names.

Lieut. R. H. Sams., B.Sc., R.E.,	...	10th March 1929.
,, C. J. Price, R.E.,	...	9th ,,
,, C. A. K. Wilson, R.E.,	...	9th April 1929.

As these officers joined late, their field work was restricted to a period of less than three months, and it was decided to give them a two-months' course of 2-inch planetabing in the hills and intricate sub-montane area.

This was followed by a fortnight's triangulation in the field, the recess season being devoted to instruction in computations, fair mapping, and the various branches of work being done by the units in Dehra Dūn.

181. *U.S.S. probationers (First year).*—Seventeen probationers joined the Training School on first appointment during the latter half of November 1928. Of these eight were discharged as unsuitable by the 10th June 1929. Each of the remaining probationers completed an area of about 4 square miles of 4-inch survey and 12 square miles of 2-inch survey. They were also given practical instruction in triangulation in the field, each probationer being made to observe at two or more stations. A newly appointed geodetic computer, and one U. S. S. officer on transfer from No. 22 Party, joined the training school in February for a course of planetabing and triangulation.

APPENDIX I.

A BRIEF DESCRIPTION OF THE NEW MAP MOUNTING MACHINE.

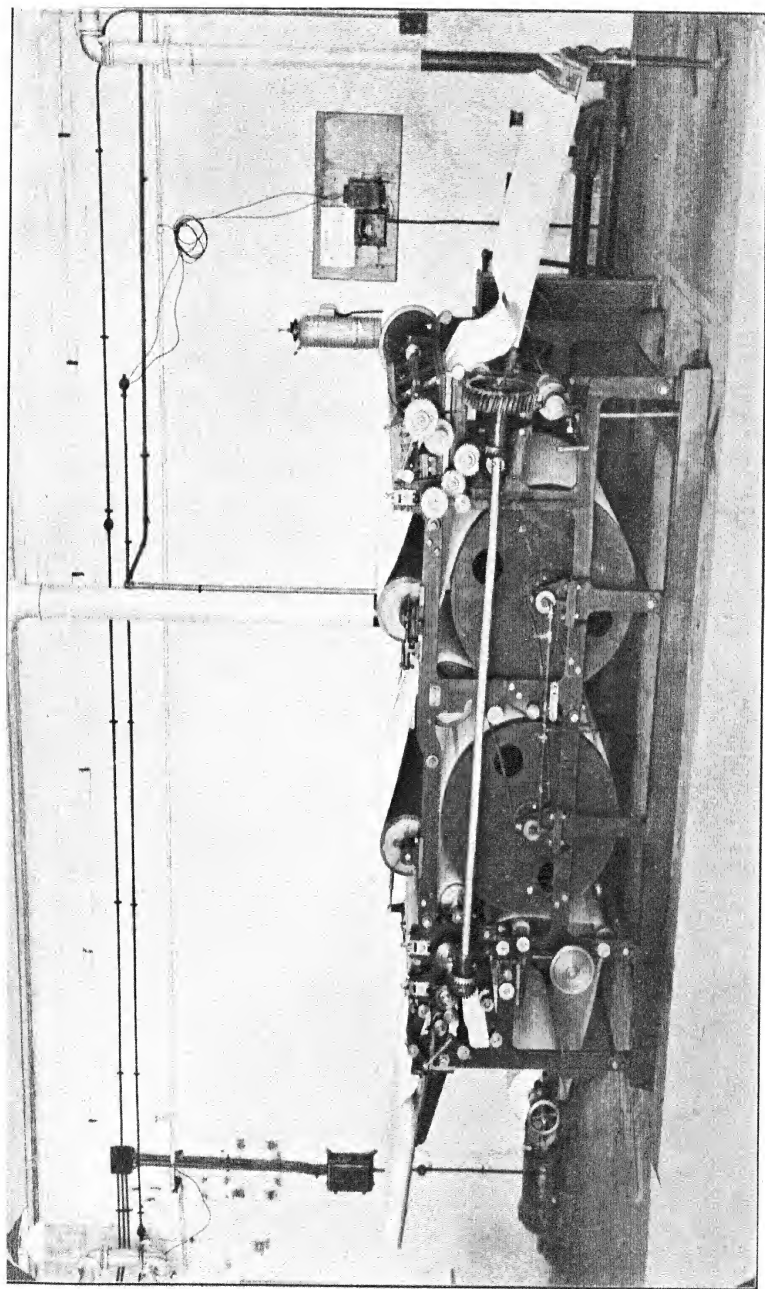
A Map Mounting Machine is being installed in the Map Record and Issue Office in Calcutta. The original model was designed by the Ordnance Survey in Southampton and manufactured by The Practical Machine Company (A. T. Gadsby) Ltd. of London. After several months spent in experiments, certain improvements were fitted to this first machine, and, during the summer of 1928, the present Surveyor General saw it at work and was informed that it was giving very satisfactory results. He therefore decided to order one for the Survey of India. This new machine, which has now been delivered, is believed to be the only one of its kind in the world, except the original model in Southampton, although it is understood that another has been ordered by the Survey Department of the Federated Malay States.

The machine is driven by a two horse-power electric motor and gas is used for drying purposes. At one end of it a length of cloth is wound round a spindle immediately below a sloping board, on which the maps to be mounted are placed. When the machine is set in motion, the cloth is carried by a couple of wooden rollers over a brass roller running in a trough containing paste, which is thus applied to the under-side of the cloth. The cloth is then led to two pairs of brass pressure-rollers, the pressure of which is adjustable. On its way, the pasted side is turned uppermost and comes in contact with the map just before passing through the first pair of pressure-rollers.

The maps are fed by hand into a specially designed drop-roller and gate-feeder, the frequency of feed being controlled by cam and cam-rod from a rotary countershaft connected with the delivery and cutting mechanism at the other end of the machine. The maps are automatically timed to follow each other in such a way as to leave no space between them. The object of this is to keep the upper pressure-rollers free from paste, which would otherwise be picked up by them and transferred to the faces of the maps as they pass under them.

A map having been fed against the pasted side of the cloth, the map and cloth both pass through the two pairs of pressure-rollers and are tightly squeezed together. They are then led, by means of a number of wooden rollers, around two large copper drying-drums which are kept heated by gas burners to a temperature of over 200° Fahrenheit. The last of these wooden rollers, which is above the second drying-drum, is adjustable in the horizontal plane, in order to take up any irregularity of stretch which may occur in the cloth.

Next, the cloth, now dried with the maps mounted upon it, is passed to a pair of draw-rollers, one of which has a felt lining. The pressure between these draw-rollers is adjustable by thumb-screws, and the rollers tend to draw the paper slightly and so take up any stretch that may have



MAP MOUNTING MACHINE.

Photo-engraved & printed at the Offices of the Survey of India, Calcutta, Ind.

arisen owing to first wetting and then drying the map after feeding. Close to this last pair of rollers is the cutting-knife. The cutter is of the rotary type, the speed of the knife being varied by means of change gears, one pair of gear wheels being necessary for each separate speed, or to put it otherwise, for each length required between cuts. The cutter and draw-rollers are driven positively by means of mitre wheels and mitre shaft. To this mechanism the feed is connected, as already explained, so that the frequency of feed is timed in accordance with the length between cuts at the delivery end of the machine.

Finally, the mounted maps slide from below the cutter on to a receiving-board. Any cloth projecting on the two untrimmed edges is afterwards cut by ordinary guillotine.

The out-turn of the machine is expected to be between three and four hundred mounted standard sheets an hour. It is hoped that its use will revolutionize the system and cost of map mounting in the Department.

